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PHILIPPINE
GOVERNMENT
LABORATORIES

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REPORT

OF THE

SUPERINTENDENT OF GOVERNMENT LABORATORIES IN THE PHILIPPINE ISLANDS

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FOR THE

YEAR ENDED SEPTEMBER 1, 1903.

[FROM FOURTH ANNUAL REPORT OF THE PHILIPPINE COMMISSION.]

BUREAU OF INSULAR AFFAIRS,
WAR DEPARTMENT.

APPENDIX G.

SECOND ANNUAL REPORT OF THE SUPERINTENDENT OF GOVERNMENT LABORATORIES.

DEPARTMENT OF THE INTERIOR,
BUREAU OF GOVERNMENT LABORATORIES,
Manila, September 14, 1903.

BUILDING AND CONSTRUCTION.

In the report of the superintendent of government laboratories for the year ending August 31, 1902, the organization of the laboratory force and the beginning of work in the temporary quarters was described.

The detailed plans of the new laboratory building were practically completed at that time, but the site for the structure was not selected. The original intention had been to locate at Santa Mesa on the highlands just inside the city limits and near Sampaloc Cemetery, where a plot of ground had been kindly offered as a gift for this purpose by the Hon. Benito Legarda. However, in attempting to carry out this idea, considerable delay was experienced by the donor in arranging a satisfactory adjustment with other owners of the estate of which the proposed site was a portion, and consequently, so as to shorten the time during which the bureau would be compelled to do unsatisfactory work in the cramped quarters leased by it on Calle Iris, it was decided to look elsewhere for an available location; with the full knowledge that in the future the generous offer of Señor Legarda would be repeated for other government institutions equally important to the intellectual advancement of the islands.

After canvassing the ground thoroughly the Hon. Dean C. Worcester, secretary of the interior, the Hon. Bernard Moses, secretary of public instruction, and the superintendent of government laboratories selected a portion of the so-called exposition grounds, the intention being to have the laboratory building front on Calle Herran and occupy ground to the east of the driveway. This necessitated the purchase of a plot owned by the church which, if not acquired by the government, would make the entire piece of land irregular in shape. This land was bought, so that 26½ acres are now included in the exposition grounds.

The new building was begun in October, 1902, according to the original plans. The foundations of concrete have been pushed as rapidly as possible; at the present time they are completed and the framing of the superstructure is well under way. It is to be hoped, with the present rate of progress, the government laboratories will occupy their future quarters in April, 1904, and will then be able to extend the courtesies of the institution to visiting scientists. Requisitions for the necessary power, boilers, pumps, and other mechanical appliances, as well as for the refrigerating plant, are now being completed, and probably all materials will be on hand to install the machinery by that time.

In the last annual report the cramped nature of the temporary quarters on Calle Iris was mentioned, but since then work has increased so rapidly that the superintendent of government laboratories found himself compelled to rent an auxiliary building on Calle Alix. The library of the bureau and the biological laboratory have been transferred to this additional space, which also gives opportunity for the storage of apparatus and supplies ordered for the new building, when an increased force of scientific workers will be available. Contrary to expectation, much of this apparatus is already needed in the present quarters, but certain pieces will remain unused until the final move is made. The requisitions were planned to include in the first shipment only such pieces of apparatus as could actually be used under present conditions, so the remainder of the supplies will probably not arrive until very shortly before the completion of the new building.

SERUM LABORATORY.

The serum laboratory, at the time of its transfer from the board of health to the bureau of government laboratories, was provided with accommodations sufficient only for about 10 vaccine calves, 15 or 20 serum cattle, and 5 or 6 horses. The demand for vaccine and rinderpest serum increased very rapidly during the last half of present fiscal year, because of the prevalence of smallpox and the beginning of the work of inoculating animals in the provinces, and in order to meet this demand the number of animals in the serum herd was increased as rapidly as possible. This necessitated the building of a quarantine station holding 40 animals in a separate portion of the San Lazaro estate, the construction of stalls in the neighborhood of the operating room, and the building of a feed barn and stables for about 200 animals. The rapid completion of these improvements was necessary in order to meet the extraordinary demand for space which would be made as soon as importations for the government from other countries would begin.

The present location was divided into three paddocks by fencing, enabling the separation of different classes of animals, and sidewalks connecting the most important buildings were added. A small laboratory for the scientific work relating to vaccine and serums was fitted up, and an operating room for the aseptic preparation of vaccine also was built. The necessity for investigating surra led to the protection of the horse stable by fly screens in such a manner as to render the spread of the disease from afflicted animals kept for purposes of study impossible, and the increased use of small animals, such as guinea pigs and rabbits, was the cause for the construction of proper quarters for this class of experimental material.

All of the structures which have been placed upon the present land have been temporary in their nature, for the reason that the portion of the San Lazaro estate occupied by the serum laboratory has been needed by the board of health for its own buildings, and because the placing of such a large number of animals in close proximity to a hospital was undesirable. The superintendent of government laboratories therefore made an effort to secure sufficient land in another part of the city and nearer to the new laboratories on Calle Herran. By agreement with the municipal board a site in Paco became available, and when the laboratory is completed at that point the location at San Lazaro will be abandoned. This plan is in every way desirable, as it will furnish the serum laboratory with a permanent location for its animals free from the objection of the proximity to hospital buildings and with the added advantage of convenience in the administration from the main laboratory.

The land in Paco is fairly high, and according to levels will probably not be flooded excepting during the severest rains, which might occur once or twice in the rainy season. During the remaining time it can be drained into an estero lying about 1,500 feet to the north. On this spot it is proposed to construct permanent buildings for the manufacture of rinderpest serum. These will probably consist of four stables for cattle, built with cement floors and metal stalls, so as to render disinfection certain and positive, an operating room for bleeding cattle, a barn for feed and supplies, and a building for the watchman. The latter will also contain sufficient laboratory space to permit of caring for the fresh blood. The preparation of the serum, packing and shipping, will take place at the main laboratory. A quarantine stable for the purpose of observing animals before they are admitted to the serum laboratory will be built at the farthest corner of the land. A photograph of the proposed type of stable is given in fig. 4.

When the permanent site is completed, the laboratory can with certainty care for its animals in a most approved way, and will be able to avoid contagious diseases among them. The drainage problem is the most difficult one, but probably can be solved by disposing of liquid sewage through a septic tank and sewer to the estero, and by collecting solid manure in proper receptacles and permitting the use of the same in certain areas of land where cattle never graze and where all animals used are immune against rinderpest. This would be feasible in the farms occupied by the agricultural bureau. The argument against using manure from serum stables will disappear in the same degree as animals present in Manila and its surroundings are immune against rinderpest.

All vaccine work and the preparation of all serums involving the use of horses or small animals only will be conducted at the main laboratory building.

LIBRARY.

Since the last annual report the purchase of books contemplated by the Commission for the permanent equipment of the scientific institutions connected with the bureau and for the reference library has continued as funds became available. The care of this material at first was so slight that it could devolve upon the stenographers and property clerk of the bureau, but in the first quarter of the present year the necessity of adequate cataloguing, accession books, and of the proper care of the library, as well as of a system by which books could be taken out by laboratory workers, became apparent, and Miss Mary Polk was appointed librarian after an examination by the civil-service board.

The buying of sets of periodicals has necessarily been somewhat retarded, owing to the distance from the source of supply and the difficulty experienced by dealers in obtaining complete lists.

The chief publications which are now on hand and complete comprise Liebig's Annalen der Chemie, Berichte der deutschen chemischen Gesellschaft, Berliner klinische Wochenschrift, Centralblatt f. Bakteriologie (all parts), Centralblatt f. die med. Wissenschaften, Centralblatt f. klinische Medicin, Centralblatt f. innere Medicin, American Medicine, Anatomischer Anzeiger, Baumgarten's Jahresbericht, Beitrage zur pathologischen Anatomie und zur allgemeinen Pathologie, British Medical Journal, Bibliographia Medica, Chemical News, Zeitschrift f. angewandte Chemie, Zeitschrift f. klinische Medicin, Zeitschrift wissenschaftliche Mikroskopie, Schmidt's Jahrbucher, Medical Review, Journal of the Chemical Society, Journal of the Royal Microscopical Society, Lancet, Hope-Seyler's Zeitschrift f. physiologische Chemie, American Chemical Journal, and all of the Johns Hopkins publications relating to medicine.

The subscriptions cover the foreign scientific and medical periodicals, and have been taken for the current year since the inauguration of the laboratory, the complete sets of the important journals being filled in subequently. There are a number of important sets which have been ordered and are now on the way. Only a few of these can be mentioned. They are, for example, The American Journal of Medical Sciences, Poggendorf Annalen d. Physik u. Chemie, Annales de l'Institut Pasteur, Archiv der Pharmacie, Deutsche medicinsche Wochenschrift, and the chief journals covering agricultural chemistry, chemical technology, anatomy, physiology, veterinary medicine, and certain portions of botany and entomology.

The necessity for periodicals covering the field of industrial chemistry has been apparent from the beginning, because many questions concerning manufacturing processes are continually submitted to the laboratories, and the chemical bulletins which it is proposed to issue will cover, if the greatest advantage to the islands is to be considered, the fields where new manufactures and improvements in the present industries can be made.

Adequate literature on veterinary medicine is needed, because the laboratories have constantly under their control from at least 100 to 125 animals, and because owners of cattle and horses are continually applying to the institution for advice. The most important sets of veterinary journals are either ordered or scheduled for the near future.

The beginning of the botanical laboratory furnishes the necessity for literature in the direction of its work. The benefits to be derived from accurate botanical investigations can be compared with similar ones to be undertaken for the purpose of advancing the chemical industries.

The biological laboratory in its work covers the ground of medicine and pathology, and the general scope of the bureau necessitates continual reference to chemical, pharmacological, pharmaceutical, toxicological, and physical literature. The library is intended to be one of maximum usefulness in scientific work, and is accessible to all persons who feel the need of referring to this class of books. In the building on Calle Alix it is shelved in a room sufficiently large to allow of its liberal use and is much more conveniently located than it formerly was on Calle Iris. A card system of cataloguing has been begun and will be completed as fast as possible. The list of actual sets on hand and of subscriptions will be given in the report of the librarian.

In the future it is hoped this library will be used by educational institutions established in the Philippine Islands and will furnish the means of acquainting the Philippine workers with modern scientific advances. The need of adequately acquainting students who are natives of the Philippine Islands with modern medical and scientific work is great, and in conjunction with a medical school this library will form the greatest incentive to the advance of medical education in the islands.

An increasing number of Philippine students are now being educated in the United States, and it would indeed be a misfortune if upon their return to their native country they should be cut off from the literature which is most important in continuing their mental growth.

APPARATUS AND SUPPLIES.

The purchase of apparatus and supplies necessary for adequate work has greatly improved the condition of the laboratories during the past year. At the time of the last annual report the bureau was very much hampered by its inability to meet a great many emergencies which it encountered, and by the fact that many makeshifts of an inadequate nature were of necessity resorted to in adjusting itself to the conditions which surrounded it. Appropriations for apparatus and supplies were made early in the career of the institution, and the orders placed in Europe and America have been gradually filled, so that the workers may be said to be fairly well equipped at the present time, although many fields of work must still remain untouched. It was at first supposed that a considerable proportion of the mechanical accessories for laboratory work would need to be stored or held up pending the completion of the new building, but experience has taught us that almost everything which has arrived so far has been put to immediate use. Some large pieces of apparatus, which can be applied only in connection with a permanent building having adequate facilities in the way of power, have not been called for, because no prospect of their use, however necessary, could be seen until space could be provided by the new structure. This statement especially refers to the machinery which will be needed for experimentation on commercial subjects and for the larger apparatus necessary for the expeditious preparation and packing of serums. The vacuum distilling plant, which will handle 150 pounds of material at a time, the large extractors and other appliances connected with the work on essential oils, rubber, gutta-percha, etc., have not as yet been ordered, but will be on hand in time for installation in their permanent quarters.

Up to the present time the laboratories have constantly been in need of microscopes, the supply always being insufficient for the demand. There are on hand five Zeiss instruments, two of Bausch & Lomb, and one Zeiss dissecting microscope, and eight more instruments are on the way. These will probably fill the immediate needs so far as the workers in the biological, entomological, botanical, and serum laboratories are concerned, but they will not more than cover this ground, and additional instruments will be purchased as funds become available.

The supply of chemical balances has been increased somewhat during the present year, but the instruments are still overcrowded. Two more are on the way. The laboratories have long felt the need of a large balance with a normal set of weights for the purpose of checking the instruments of other bureaus of the government, and a set of apparatus to cover this demand has been ordered, but is not yet on hand. An adequate assay outfit to meet the demand for this class of work has been ordered. In the meanwhile, the only available place for assaying is at the mining bureau, the laboratory of which has been placed at our disposition through the kindness of Messrs. Burritt and McCaskey. The complete appliances for assay work in the bureau of government laboratories will probably arrive in the near future. The laboratories are fairly well supplied with microtomes and other large biological apparatus, with platinum ware and appliances for carrying on routine work.

Experiments with the purpose of furnishing an adequate gas supply have been carried on, and toward the close of the year 1902 a machine for preparing gas from cocoanut oil was purchased, the principle of which is one of destructive distillation of the oil in a red-hot iron retort. The amount of fuel consumed and the quantity of oil necessary for supplying the building has not been great, and the gas has been of a quality equal to that supplied by any of the larger institutions.

At present the chemical laboratory uses about 200 cubic feet per day. Results with this type of apparatus have been so satisfactory that it is proposed to install the same class with a larger tank capacity in the new building.

CHEMICAL LABORATORY.

The chemical laboratory has been compelled to meet a continual call for work from other bureaus, many of the analyses being complex and taking a considerable amount of time. Its force has been limited chiefly because of the lack of room, and also for the reason that it has been difficult to obtain chemical workers from America.

The range of work was varied. A number of analyses of suspected counterfeited silver coins for the custom-house and treasury were made; examinations for poisons, some of which were for chemico-legal purposes, and involved testimony in court, were undertaken, and investigations of stains, in cases of suspected murder, for the purpose of determining the presence or absence of blood have been asked in two instances. Analyses of mineral and other waters have been asked, and requests for reports on soils, coals, paints, alloys, etc., have been made. The exposition board has submitted a large number of minerals for assay and for partial analysis, and the work in this direction has been pushed as rapidly as the force would permit, one man being continually detailed for this purpose. It is hoped the results of a systematic series of assays will give us a fairly clear conception of the distribution of gold and silver in the islands. The samples so far submitted have come from northern Luzon, Masbate, and Camarines. In preparing the exhibits, if the materials can be furnished, as large a number of coal analyses as possible will be made, and the laboratory will endeavor in other ways to assist in determining the chemical nature of many of the exhibits to be sent to St. Louis.

Unfortunately during the past year the limitation has been such that no one chemical worker has been able to devote his time to research work, and such investigations as have been accomplished have been undertaken at odd moments when for the time being no large pressure of analytical work was felt. It has, however, been the aim of the laboratories to completely finish the work on india rubber and gutta-percha which it began in the past, and in order to prepare a complete bulletin on the subject in time for the exposition at St. Louis, Doctor Sherman has been sent on a second expedition to the southern islands with the purpose of completely filling in those portions of his previous work which had been left open. This subject it is to be hoped is now exhaustively covered, and a map showing the distribution of gutta-percha and india rubber, together with the methods of collecting and marketing the same, will form an excellent guide for manufacturers and producers.

A brief exploration of Mindoro was also undertaken by Doctor Sherman, where a new source of rubber was discovered, the latter being apparently of a superior quality. Samples of this product have been submitted to manufacturers in America for valuation.

The superintendent of government laboratories, together with Doctor Sherman and representatives from the mining and agricultural bureaus, made a trip to Paragua, because it had been reported that the true Dichopsis gutta occurred in this little-known island. Although the region was covered from Tai Tai in the north to Balabac in the south, neither gutta-percha trees nor india-rubber vines were encountered, the results proving negative in this respect, excepting in regard to the valuation of Paragua as a gutta-percha and india-rubber producing region.

The location on this island of the tree producing gum dammar was studied, and a considerable quantity of the resin brought to Manila for exhibition purposes and for investigation.

Accompanying the india-rubber and gutta-percha investigations, the laboratory has endeavored to undertake a course of study of the gums and resins of the island, and Mr. Bliss began, and has to a large extent completed, a line of work comprising the so-called "brea." The examinations so far conducted have shown that a number of trees produce products similar to the "brea" of commerce, from which oil of elemi is extracted. The essential oils obtained from these various sources varied, and one sample produced a large percentage of almost pure pinene. The particulars of this work will be given under the report of the chemical laboratory. Examinations of manapo oil, panao oil, tapulao resins, and others have been undertaken, and it is hoped that in the course of the next year, with a sufficient laboratory force to push the work, a systematic report, covering a large percentage of the gums and resins of the islands, can be prepared. Two samples of mineral oils have been brought to the laboratory for analysis, both being surface oils. The nature of one of these was such as to warrant the advice for further exploration.

The advantages to the government of the chemical laboratory, in addition to the necessary analytical work demanded in the Philippine Islands, must lie in systematic investigations of the resources of the archipelago, in the study of methods for improving present manufacturing conditions, and in demonstrating the value of products at present neglected. It would, for example, be of the highest importance if a sufficient force of workers were on hand to systematically investigate the possibilities of cement production, and a bulletin giving complete data on this subject for the benefit of the government and of manufacturers would be of sufficient value in cheapening the price of cement to pay for the expense of the undertaking. The same conditions apply to coals. A systematic determination of the value of Philippine coals, based upon a complete series of analyses and investigation of the fields, would finally place our knowledge of this important product upon a firm and definite basis.

While the islands produce a considerable number of essential oils which have a sale in the markets of the world, it is unquestionably true that many flowers as yet unstudied would increase the range of this class of products, and activity in this line will be undertaken as soon as apparatus for the proper carrying on of the work is available. The vegetable products of the archipelago in relation to the preparation of alkaloids and other substances of value in medicine have not been studied from a systematic point of view in the laboratory, but indications which we have had in the past show us that in the future a large field exists for this class of research.

The chemical laboratory will only demonstrate its true value to the government if it can have a sufficient staff to enable it to properly carry out investigations of the class outlined above. The routine work and analyses need to be done, but the largest returns must be expected from research work tending to improve the commercial conditions of the islands. Besides inadequacy in the force at present available, the laboratory has been hampered by lack of collectors. In order to systematically survey a field such as would be necessary in the study of cement products or of coals, it will be essential to have men at the command of the institution who can be sent to the various regions of importance to completely survey and map the territory. Such research work as has been attempted in the past has always been hampered by the fact that the source of supply has been intermittent and substances have been investigated which have come from widely different areas in the islands and which presumably have no connection.

Vegetable products of economic importance are often brought to the laboratory, but the statement as to their source, the trees or plants from which they come, and all other data are so meager that no basis for report of value on the extent or distribution of the products derived from them could be made. In the case of india rubber and gutta-percha the bureau was compelled to spare its leading man in the chemical laboratory in order to obtain proper data for the preparation of a bulletin on this subject. In future requests for appropriation a collector for the chemical laboratory will be asked for, and it is hoped that within a year the institution will be in a position to investigate commercial subjects covering an extended area and to prepare bulletins of great value for the economic advance of the islands.

THE TRANSFER OF THE SERUM LABORATORY FROM THE BOARD OF HEALTH.

On January 30 of the current year, act 607 of the Commission transferred the serum laboratory from the board of health to the bureau of government laboratories, and Dr. James W. Jobling was appointed director of the serum laboratory. Some development of this portion of the bureau had taken place under the board of health, but owing to varied duties of that body, as specific attention as was needed could not be given to the preparation of serums and vaccine; as a result, the vaccine virus used in the islands had deterioriated through successive years until it was of but little value. The preparation of rinderpest serum had suffered a set-back by the introduction into the paddocks of foot-and-mouth disease, and the absence of virulent blood to keep the immune heard in the state of highest efficiency.

The energies of the new director were at once turned toward obtaining a herd free from all disease, to quarantining all animals in future admitted to the laboratory, to improving the vaccine virus by a fresh importation from Japan, and to obtaining a regular and sufficient supply of small animals, such as guinea pigs and rabbits. With the addition of the buildings mentioned above the serum laboratory was soon in a condition to do efficient work. Foot-and-mouth disease disappeared, the systematic care and feed of the cattle brought about a betterment of their conditions, and since the first of February the laboratory has never lacked for efficient vaccine virus and for a sufficient quantity of rinderpest serum. The heard of immune cattle has lately been increased to about eighty animals, and new ones are being purchased as opportunity permits. The great call for its serum is evidenced by the fact that over 4,000 animals have been immunized in the provinces; that several thousand doses have been shipped to Shanghai for use with the Government cattle to be imported, and that some quantities have been sold.

The demand for vaccine virus has been unprecedented, and during the past six months 900,000 doses have been prepared. The board of health has made an extended call for Shiga prophylactic against plague, and up to the present time some 4,000 c. c. of this substance have been placed at its disposal.

The necessity for plague serum has always been felt, and the only reason why it has not been manufactured in Manila has been from lack of means and the possibility of systematic work. The serum laboratory began the purchase of horses as soon as it was transferred to the bureau of government laboratories, and now has on hand five animals which are rapidly being brought to the point where they will yield serum of good efficiency. Eight hundred cubic centimeters of antipestic serum have already been prepared and disposed of. The rapid development of this work, the health of the animals, and the discipline and system prevailing in the serum laboratory reflect the highest credit on its director. The facilities of the laboratory will be increased as time goes on, and the bureau will soon be in the position to furnish on demand all classes of serums and prophylactics which may be needed in the islands.

The laboratory has cooperated with the board of health in inoculating cattle against rinderpest, and expeditions, composed of employees of both institutions, have been sent to various parts of the islands. At the present time every assistance in the power of the bureau is being rendered the insular purchasing agent in the care of the animals which are being imported for the purpose of restocking the islands.

The connection which the laboratories have had with the importation of horned animals has brought to its attention the fact that practically a number of diseased ones arrive with each shipment. This condition emphatically calls for the establishment of a cattle quarantine station at Manila and for the necessary improvements thereon to enable the board of health to efficiently and promptly handle all shipments; to control sick animals; to inoculate such as need this treatment, and to prevent the introduction of further disease into the islands. After the work of inoculation has been extended over the Archipelago, it will be necessary to prevent the reintroduction of rinderpest, and quarantine stations at the main ports of entry in the provinces will be the only means by which this can be done.

The pressure of work on the serum laboratory has been so great that none of the employees have been able to devote any time to investigations, all of their energies being directed to the actual manufacture of serums and prophylactics, which are in steady demand. The scientific force has been very limited; in fact it may be said that the director is the only one in this laboratory who has had adequate experience and training, with the exception of Dr. John G. Slee of the board of health, who has practically been detailed to the serum laboratory, and whose assistance has been of the greatest value. Unfortunately the emergency brought about by the purchase of cattle at Shanghai has rendered it essential to send Doctor Slee to that port, and this has left the laboratory without his efficient help. This condition has been felt by the Commission, and an effort has been made to secure the services of a thoroughly trained assistant director from America. As yet the government has not been able to ascertain whether the proper man has been found.

The advantages of research work in the serum laboratory are obvious. If, for example, careful investigations would develop means to so increase the potency of the rinderpest serum as to diminish the necessary dosage by one-half, the expenses of the laboratory would be cut down in proportion, and the same is true of all other lines in which the institution is engaged. In the course of the next year it is hoped that a sufficient number of scientifically trained men will be on hand to obviate the danger of loss in efficiency to the laboratory through sickness or other causes, and to enable it to carry on investigations which will diminish the cost of production and increase the efficiency of its products. The immunization of cattle against rinderpest is more successful and in better operation to-day in the Philippine Islands than in any other part of the world. The perfecting of the technique of this work and its successful application are due to the efforts of the bureau of government laboratories, and with such results to point to, it is but fair to its employees to recognize that they can not continue unless a sufficient number of men are engaged to enable the ones on hand to have some time for rest and recuperation, and opportunity for the more interesting phases of original work. The details of the work of the serum laboratory will be found in the report of the director.

BIOLOGICAL LABORATORY.

During the past year the force of the biological laboratory has been augmented by two men, Doctors Wherry and Wooley, who arrived in Manila on January 28. These additional workers formed a welcome increase in the laboratory force, because the pressure of the diagnostic work for various hospitals and bureaus had become so great that the limited number of men on hand were no longer able to keep up with it. During the past six months the demand for this class of assistance from the bureau of government laboratories has increased very rapidly, approximately 7,000 diagnoses having been made. In addition 20,000 rats and mice have been received at the laboratory for examination to determine the presence or absence of plague, 4 medico-legal cases

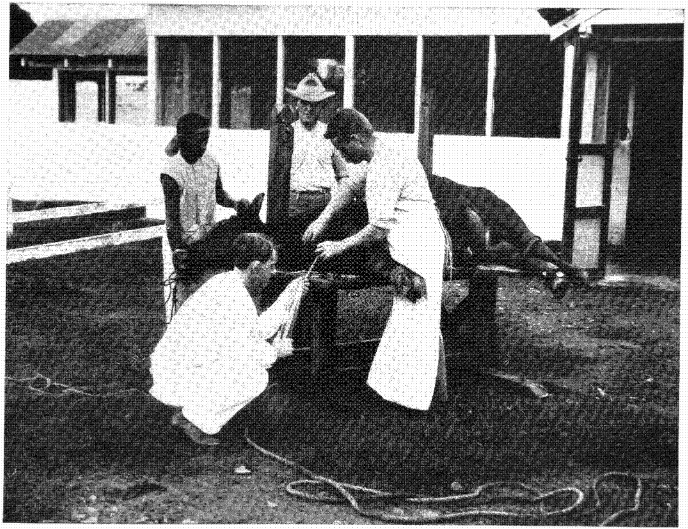

FIG. 10.—BLEEDING AN ANIMAL FOR ANTIRINDERPEST SERUM, SERUM LABORATORY.

UofM

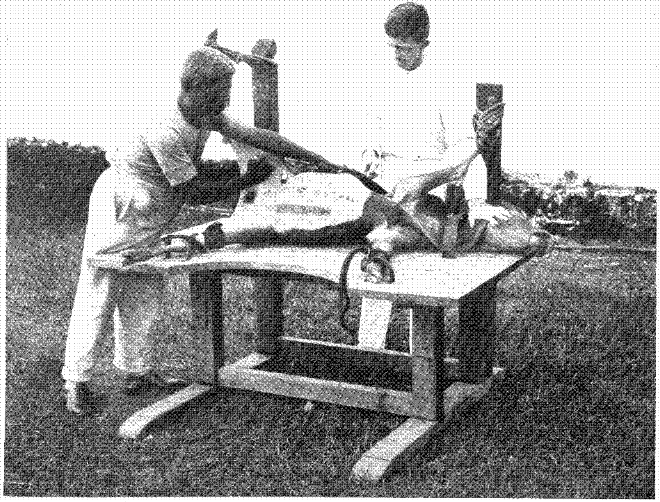

FIG. 11.—METHOD OF PREPARING VACCINE AT SERUM LABORATORY.

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have been handled, 500 tissues prepared for microscopic work and a large number of post-mortem examinations undertaken.

For a time culture media prepared in the biological laboratory were furnished to the serum laboratory, but subsequently this was found to be inexpedient and the serum laboratory is now manufacturing a large proportion of its own.

Endeavors to do research work have been limited by the demand for diagnoses, and the same conditions prevail in the biological laboratory as are found in the chemical and serum laboratories and the same need exists for a sufficient force to enable men here to take some recreation and rest. The largest piece of investigation has been that of Trypanosoma and Tripanosomiasis by Doctor Musgrave, assisted by Messrs. Clegg and Williamson.

One of the duties of the force of the biological laboratory which interferes with the use of their time in their proper sphere of work lies in the clerical details which need to be performed in the entering and filling out of the prescribed blank requests for diagnosis. This portion of the work of the bureau could more properly be performed by a man who could be engaged at a much smaller salary than the scientific corps should receive, and it is to be hoped that a record clerk to take charge of these duties will be authorized at the beginning of next year.

The biological laboratory, just as is true of the chemical laboratory and the serum laboratory, will need to have a sufficient force to enable it to do research work. The exposure of a community in the Tropics to the various diseases incident upon its location is constant, and the importance of an adequate study of the results of tropical infection and their causes can not be underestimated.

The laboratory force in an institution such as the biological laboratory should be, for practical purposes, divided into two sections, the clinical section, which has to deal with diagnoses, and the pathological or research section, which devotes itself to the investigation of tropical diseases. All men in this line of work coming from the United States necessarily lack training in the field of tropical diseases, and the proper system should be to have them first take up work in the clinical section until they are acquainted with the various affections which they may encounter. Much of the clinical work is interesting, especially to those beginning tropical work, and a moderate amount of it broadens the pathologist and furnishes data for investigations. On the other hand, a continuous grind at the microscope, without time to follow up interesting results, becomes monotonous, and in the end decreases his efficiency. After ample experience has been gained, the employees in clinical work should have an opportunity to be promoted to the research division whenever vacancies exist. The gradual increase of the number of employees engaged in biological research work is looked for, and it is to be hoped that in the course of the next year even more important results with research work will be accomplished than have been shown during the twelve months just ending.

Dr. W. E. Musgrave was acting director of the biological laboratory from December 15, 1902, to July 15, 1903, taking the place of Dr. Richard P. Strong, who was absent in Europe on leave. Doctor Musgrave, in addition to his numerous duties, was able to prepare a very extensive and creditable investigation on the subject of "Surra," carrying on his work in the fly-proof stable at the serum laboratory. His results in brief have already been published in a preliminary bulletin, and the extended report is soon to appear.

The study of surra in the Philippine Islands has made it evident that this is one of the greatest dangers to which domestic animals can be exposed. The loss by death of horses contracting this disease in the Philippine Islands has been enormous, and consequently the investigations carried on by Doctor Musgrave formed a basis for the recommendation to the board of health of a quarantine law for horses imported into the islands, and also as to the means of destroying the infection at present existing. It is to be hoped that some action on this subject can be taken by the board of health and the Commission in the near future. Recently another disease of cattle was introduced from China. The value of efficient laboratory service was demonstrated by the fact that the disease was recognized, its nature and dangers determined, and steps taken to prevent its spread by the force of the serum and biological laboratories within a week of its appearance.

Doctor Strong returned to the islands on the 15th of July, after having spent a number of months in study in Berlin, and no doubt the results of his experience will be seen in the important research work which will be produced from the laboratory in the next year.

ENTOMOLOGICAL WORK OF THE BUREAU OF GOVERNMENT LABORATORIES.

Mr. Charles S. Banks, after passing the civil-service examination, was engaged by the bureau of government laboratories on December 9, 1902, and was immediately dispatched to Negros for the purpose of studying the insects which are destroying or interfering with the growth of the cacao plant, and also for suggesting such remedies as may be possible in destroying parasites attacking this valuable shrub. His work covered four months, and was mainly carried on at Maao, where large plantations exist. Inasmuch as no work had previously been done in the economic entomology of the Philippines, nothing was known practically of the extent to which cacao is injured by insects. It was therefore necessary to gather all data on insects affecting the plant in general, including roots, trunk, leaves, flowers, and fruit. A large number of specimens were collected, covering all forms of insect and myriapod life found upon the cacao trees, a collection secured of forms attacking the roots, including eggs, larvæ, and adults, and other forms attacking the branches, twigs, leaves, flowers, and fruit. A number of specimens of the wood which had been attacked were secured in connection with the insects causing the destruction, and many photographs were taken.

A few other places in Negros were also visited by Mr. Banks, and through this increased range of his studies he came to the conclusion that the insect pests are alike on all plantations in that region. Since his return to Manila Mr. Banks has been engaged in working up and classifying his material, and the results will soon be published in a bulletin which it is hoped will be of great value in assisting cacao growers to preserve and protect their plantations. The value of bulletins of this nature, founded upon actual experience, is great, and if the entomologists of the laboratory assist the agriculturists by such means the value of their services to the general public will soon be recognized. An assistant entomologist, Mr. J. L. Webb, was secured at the instance of the forestry bureau for the purpose of studying the insect life harmful to the forest growth of the islands. As yet his work is not far enough advanced to speak of the results accomplished thereby.

The prevalence of malaria, surra, and other diseases transmitted by biting insects demonstrates the necessity of a systematic study of the mosquitoes and biting flies of the islands and the adoption of means for their extermination. An entomologist can not be engaged in problems involving agriculture in one district and in work on mosquitoes in another at the same time, and the need of more workers in the field, so as to enable the bureau to cover at least a portion of the ground in a reasonable time, is evident. It is hoped the entomological division will not only show rapid progress in the future, but will also be able to attract investigators from other parts of the world.

THE TRANSFER OF THE BOTANICAL WORK TO THE BUREAU OF GOVERNMENT LABORATORIES.

Botanical work is continually demanded by at least three bureaus of the government, and it would therefore seem logical, following the plan adopted with other laboratory work, to combine all botanical work under one head, and the bureau of government laboratories would obviously be the institution where it could best be cared for. The library already is partly organized, and much of the equipment needed by other scientific workers in the bureau is the same as that which would be employed by the botanists, so that obviously this course would prevent duplication both of equipment and of books. The interests of the government laboratories frequently lie in directions which are concerned with the properties of medicinal plants, dies, tanning substances, gums, and resins, and are therefore immediately associated with the work of systematic botany, and moreover vegetable pathology is closely allied to other lines of pathological work.

The question of identification of plants will therefore constantly arise in the bureau, and botanical work would need to be carried on in it. The result, provided botanists were engaged in other bureaus as well, would be a duplication of work. The present status of botanical investigation, being divided as it is between the bureaus of agriculture and of forestry, entails more or less loss of time, owing to conflicting demands, and also more work than one man can hope to accomplish.

At the present time it is impossible immediately to secure more botanists, nor will it be possible for the laboratories to give all the space to botanical work which is necessary, but the transfer of such force and equipment as is now on hand could be made at once, and during the next six months assistants could be obtained from America. The demands at present call for at least one assistant botanist to help Mr. Merrill, the botanist, in the work, and for two collectors, who should be qualified to go to the provinces and obtain material. At least one man should be in Manila all the time to care for the material which is coming in. This involves a force of four men at the present, and it is believed that, with careful training, well qualified assistants can be developed from among the natives of the islands. The botanical collectors, if in the bureau of government laboratories, could also assist in bringing in material which is necessary for chemical investigations, and would thus materially advance the interests of the entire institution.

If the transfer of the present botanist of the agricultural bureau to the bureau of government laboratories is accomplished, and when his assistant and two collectors are on hand, it is certain that the bureau of government laboratories can carry on work satisfactory to the other departments of the government which are interested in this line of investigation. In the new building sufficient space for laboratory work and for herbaria can be furnished. When the clerical force of the bureau is fully organized, it will be able to carry on the work of cataloguing and classifying the material belonging to the botanical laboratory as well as that of the entomologists. Eventually it will be advisable to organize a botanical laboratory under a director, who should be a thoroughly trained plant pathologist and physiologist. This director should be obtained during the course of the next year.

The agricultural and forestry bureaus have purchased a number of books and sets relating to botany, which, after January 1, 1904, should be transferred to the library of the bureau of government laboratories. The bureau itself will endeavor to round out and complete the botanical library and will thus consolidate one more line of scientific work with the central organization.

Original specimens should be kept in the laboratory herbaria and duplicates sent to the various scientific institutions for identification. It is certain that the organization of the botanical laboratory according to this plan will result as successfully as it has in the case of the chemical, biological, and serum laboratories.

THE WORK OF MAKING MICROSCOPIC SECTIONS FOR THE FORESTRY BUREAU.

In accordance with a request submitted by the chief of the bureau of forestry, Mr. J. J. Eaton, of the bureau of education, was engaged in the bureau of government laboratories during his vacation for the work of preparing microscopic sections from the different kinds of wood found in the Philippine Islands. In all 48 varieties were examined.

Some difficulties were experienced in softening the wood tissues so that they might be cut with a microtome, but a 20 per cent solution of potassium hydroxide finally proved fairly satisfactory. The softening of the various kinds of wood takes from four to twenty-four days, according to the variety, some extremely resistent ones requiring heating with the solution in an autoclave. After softening and removing water by means of successive alcohol baths, the tissues were mounted in celloidin and cut by the microtome. The results were in every way satisfactory, as it developed that different kinds of wood and the qualities thereof could be readily determined by this means. Specimens of two of the photomicrographs taken from these sections demonstrate this fact. The preliminary report of Mr. Eaton is appended, and the complete results of his work will be published in conjunction with the bureau of forestry.

THE LABORATORY OF WEIGHTS AND MEASURES.

The proposed laboratory of weights and measures was mentioned in the last annual report, and since that time the necessity for such an institution has become more apparent. Requests for certification of weights and measures are now frequently made of the bureau, but so far it has not been able to meet the requirements. A certain amount of this class of work can be undertaken when the balances and standard weights arrive, but it will not be until a physical laboratory is completed that systematic and comprehensive results can be expected. This laboratory is of the highest importance, and it is recommended that a physical chemist and assistant be engaged as soon as the new building is ready for occupancy. Most of the apparatus needed for this work will be on hand at that time, and steps are now being taken to order a number of more important pieces, including a dividing engine for lineal measurements. A charge should be made for business done for private individuals, and this would materially add to the income of the laboratory.

THE MARINE BIOLOGICAL LABORATORY.

The feasibility of establishing a marine biological laboratory in conjunction with the bureau has been in the mind of the superintendent of government laboratories since its organization, but the conditions did not seem favorable for suggesting this new departure in laboratory work in the Philippine Islands, because the efforts of the persons interested in general laboratory work necessarily were directed towards establishing those lines which were more immediately necessary and which could give results, the advantage of which would be obvious in the beginning. It is, however, certain that the study of so large and important a source of food supply as is given by the marine life in the waters surrounding the archipeligo can not be indefinitely neglected. The field for investigation is enormous. The activity of the laboratory would be limited only by the means at its disposal, and the results would be extremely valuable both from an economic and a scientific standpoint.

It is to be realized that the value of such a laboratory, just as is the case with all others, can not be measured from the standpoint of commercial advantage only. The islands and the people are advancing in civilization, and in order to encourage this advance no more interesting and important line of work than that undertaken by a marine biological laboratory can be mentioned. The central institution for this class of work might with advantage be located in Manila, where an aquarium, such as is found in the city of Naples, although not so elaborate, would add greatly to its value as an economic institution; substations could be established at other points in the islands, and proper dredging machinery could be attached to one or two of the smaller government vessels without great expense. It is apparent that a marine biological laboratory should be organized, if at all, as a branch of the bureau of government laboratories, because the same arguments in regard to duplication of laboratory facilities, apparatus, and workers apply to it as do the other established divisions of the work.

SCALE OF CHARGES FOR LABORATORY WORK.

During the past six months an important move has been made by the laboratory in the adoption by the Commission of a resolution authorizing work for private parties according to a scale of charges to be approved by the honorable the secretary of the interior.

Manila has been without adequate private laboratory facilities, and physicians requiring diagnoses or business men and others needing analyses have been compelled either to forego the results which were needed or to send material to other countries. This has been obviated by the present system, and a steadily increasing income has been brought to the laboratories, the chief demand having been for mineral assays.

The serum laboratory as yet has not been authorized to sell its products to private individuals, nor indeed has this been feasible, because no surplus has been on hand. It is, however, obvious that once the plant is established and the manufacture of serums well under way, a very slight addition in the cost of the whole will enable the laboratory to supply serums and prophylactics to the outside world. A small beginning has already been made in the sale of antirinderpest serum to parties in Shanghai, and it is hoped that this business can be increased in the various tropical countries to such an extent that a large share of the expenses of the serum laboratory will be met thereby.

A scale of charges for work done for other bureaus has been in force for the past six months, and the result shows the actual money value of the work performed by the bureau of government laboratories. However, the fact that such a course necessitated a duplication of appropriation has led the Commission to change the conditions in such a way that now the laboratories will need to submit only an annual report of the value of such laboratory work, had it been charged according to the same scale of prices as is adopted for private individuals.

THE CLERICAL FORCE OF THE LABORATORY.

The laboratories have depended upon the two stenographers of the bureau for all clerical work since its organization and up to the 1st of January. This was possible because the large orders from abroad had not been received, and the amount of property and the necessity for issuing considerable quantities to individual employees was not so great as to seriously interfere with the correspondence of the bureau. When, however, large shipments began to come in, and when a storeroom where individual appliances could be kept was established, a clerk to adequately care for the property of the bureau and to protect the interests both of the government and the superintendent of laboratories became necessary, and Mr. H. S. Peabody, stenographer to the superintendent of government laboratories, was promoted to the new position. The development of the library then necessitated the employment of a librarian, and this change actually brought into the bureau two clerks in addition to the stenographers, and the growth of the serum laboratory, together with the important records which needed to be kept in regard to all animals purchased, inoculated, and sold by the bureau, rendered clerical assistance for the serum laboratory imperative.

Even with this force the work during the past six months has increased in such a measure that all the employees engaged in the care of property and of records were compelled to work overtime. A laboratory uses daily many hundreds of small items, such as test tubes, pipettes, burettes, surgical instruments, needles, knives, etc. It requires feed and other supplies for the care of the cattle and incidentals such as lime and carbolic acid for disinfecting the stables; it must account for all animals purchased; must handle numbers of small animals, such as guinea-pigs and rabbits, so that in a thousand and one ways, the proper preservation of the property of the bureau becomes a great task. In order to have supplies available in sufficient quantity so as to enable laboratory work to be carried on, purchases must be continually made and a careful account kept of the condition and quantity of all chemicals and apparatus on hand. When certain things are called for in a laboratory they are frequently needed at once, and in amounts sufficient for the purpose for which they are to be used. Delays may often cause not only serious inconvenience, but great loss, so that a constant and proper knowledge of what is available is necessary. The details of requisitions, although they may not amount to a great sum in actual money value, nevertheless, consume much time. Since the 1st of January the scale of charges has gone into effect, and the property clerk of the bureau, who was the only person available, was made cashier. The checking of all blanks to prove the scale of charges to be correctly applied, the handling of the returns, and the keeping of books thus added materially to the clerical work. A well constituted and efficient clerical force will in the long run save much more money than it costs, not only in preventing abuses incident to a careless handling of property, but also in keeping supplies of the proper quality and in sufficient quantity on hand without allowing extravagance, and in administering the somewhat complex scale of charges. For this reason it has been proposed by the superintendent of government laboratories to maintain a bonded clerk and cashier, who shall have general supervision over the property and who shall have direction of all clerical work in the bureau, which later will be placed in a separate laboratory division termed the "clerical division." An additional duty devolving upon this cashier and upon his employees will be the proper maintaining of time and pay rolls, as well as the control of the janitors and laborers employed in the laboratory buildings, together with the supervision of the immediate care of the apparatus in stock. Delicate pieces of scientific machinery rapidly deteriorate in this country if constant vigilance is not exercised. It is believed that all necessary work can be accomplished by the employment of one bonded officer in charge of the clerical division, a property clerk, a record clerk for assistance in keeping scientific records, an employee for general clerical assistance, the clerk of the serum laboratory, and the necessary stenographers for the several directors. This clerical force will be constantly busy on full time, and would be sufficient to allow legal leave of absence to its employees, a condition which is now impossible.

A BILL FOR REORGANIZING THE LABORATORY AND FOR PROVIDING AN ADEQUATE FORCE FOR THE SAME.

The history of the bureau has been such that advances have been made along the lines which experience has demonstrated to be most necessary. Employees have been engaged from time to time, some from the United States and others from the Philippine Islands, as the needs increased, at such salaries as might secure a reasonably stable personnel. A graded system of remuneration could not be inaugurated because it was almost impossible to predict what the demands of the laboratory would be, hence all consideration of this desirable system was postponed until the superintendent could be certain of his ground and sure of the knowledge that all positions which would be requested could be properly filled. A draft of a bill reorganizing the bureau has been submitted to the Commission for final action, and in this the plan for graded salaries has been rigidly followed. If it is adopted employees can enter the laboratories at the lowest point, for which it is hoped a remuneration of $1,400 per annum will be authorized. Opportunity for advance to the highest salaries in the bureau by promotion through regular steps, all of which are connected, will then be given.

Evidently such a system can not be put into effect at once. Considerations of justice to the present employees must be taken into account, so that the bringing in of such a scale of salaries must be gradual until the authorized positions are all filled. This final condition should be reached within a year and a half from the present writing. The bill was so drawn as to give the ultimate positions and salaries, but these would not go into effect until by resolution of the Commission the positions should be duly authorized.

Experience has shown that in some respects act 156, organizing the laboratories, and act 607, amendatory thereof, do not cover the ground necessary for the permanent institution, although both acts have admirably met the conditions up to the present time. The duties of the superintendent have greatly increased in scope and complexity. The buildings and property under his charge have been added to, bulletins have been published, for which a uniform system of editing is necessary, and when the new building is occupied its care and the use of all materials for general scientific work, as well as of employees who can not be assigned to any one laboratory, must fall entirely under the superintendent. For this reason the power of the superintendent has been somewhat increased in the proposed draft of the bill. In it provision is also made for the publishing of bulletins and for a plan by which the bureau can offer its facilities to visiting scientists or to such as wish to carry on research work in its buildings and subject to its rules.

The time has almost come when the superintendent will be able to accommodate prominent scientific guests who wish to come to the Philippines for the purpose of research work, and it is earnestly hoped that the Commission will make provisions for such visitors, giving them the privileges of the laboratory, and, in certain selected cases of men who come here by invitation, paying their expenses from their point of departure to Manila and return. It is believed by the superintendent that, provided guests come to the laboratories under these conditions, the results of their investigations should be available for publication in the laboratory bulletins. The advantages to the islands of the presence, for limited periods, of masters of scientific investigation engaged in various lines of work, will be far in excess of any expense which such investigations will involve, and in order to prove this standpoint it is only necessary to call attention to the great benefits which have accrued to the world at large by the scientific tours authorized by various governments in the past.

THE COOPERATION OF THE BUREAU WITH SCIENTIFIC SURVEYS IN THE UNITED STATES.

Suggestions have been made in the past for the establishment of adequate scientific surveys of the Philippine Islands to be conducted by bureaus in Washington. It need scarcely be pointed out that the bureau of government laboratories, with its efficient library and its facilities for accurate scientific work, will be a great aid in cooperating in any plans which may be perfected in this respect. Botanical and geological surveys can have their matter classified or their mineral analyses made on the spot; a guide would be given in this way for the next steps which expeditions of this character would make, and the knowledge of certain regions of the islands would be markedly increased by cooperation. The scientific staff of the laboratories will always have in its midst men of experience in tropical conditions as well as in the geography of the islands and in the distribution of its various natural resources. By their advice and cooperation, workers coming from America, whose knowledge of such conditions must necessarily be limited, will be materially assisted. The superintendent of government laboratories believes that any plans formed at Washington looking toward the scientific surveys of the islands, should take into consideration the facilities for work already on hand and should be mutually elaborated by the home forces as well as by those engaged in scientific work in the Philippine Islands. A separation of the two would only result in a disadvantage to both, and a candid and frank recognition of the merits of the work both in Washington and in the Philippine Islands will be the only method by which the best results can be obtained. If a system of exchange between employees in the bureau of government laboratories and those in similar lines of work in Washington could be arranged, it would tend to bring the institutions into closer contact and would be of material advantage to all concerned.

THE WORK OF THE GOVERNMENT PHOTOGRAPHER.

During the year the government photographer has been kept steadily at work, chiefly in taking negatives of interest from an ethnological standpoint. He has accompanied members of the bureau of non-Christian tribes on expeditions to Benguet, Bontoc, and Mindoro, has taken over 500 negatives and made more than 2,000 prints therefrom, and has thus obtained a permanent record of the conditions prevailing among non-Christian tribes in the islands, as well as of their manners and customs. This series of negatives must be of greatest assistance in a scientific study of the peoples of the Philippines. Some of the tribes, by reason of changed conditions, will necessarily gradually abandon old customs, conditions may change by reason of intermarriage, migration, or changed environments, and the permanent record obtained by these photographs will then serve as a gauge to the degree of variation.

Other bureaus, such as those of forestry, architecture, and agriculture, have made use of the government photographer, and in one instance photomicrographs of textile fabrics have materially assisted the custom-house.

The pressure of work has become so great that an assistant photographer has been engaged, and by this means many demands which have been delayed owing to lack of time have been met. The making of photomicrographs must be done in the nighttime, and the result has been that in order to meet requests in this direction the photographer has steadily been compelled to work overtime. It is hoped that this condition can in the future be remedied by the increased assistance which has been accorded, but it would also be reasonable, provided the demand for photographs increases in the future as rapidly as it has in the past, that the photographer be allowed pay for overtime work.

DWELLING HOUSES FOR GOVERNMENT EMPLOYEES.

The surroundings of the employees of this bureau have never been satisfactory. Rooms or houses within reasonable distance of the laboratory have been difficult to find, and such as are available are not infrequently very undesirable from a hygienic standpoint. Illness of employees has crippled the laboratory force from time to time. When the bureau is moved to the Exposition Grounds it will probably be even more difficult to obtain suitable quarters at a reasonable rental. It is believed that the benefits which would accrue to the service, not only in the bureau of government laboratories but in others as well, by the building of adequate and satisfactory government houses for government employees would be very great. The possibility of obtaining good dwelling places at a reasonable rental would improve the service because of the greater contentment of the employees, their more efficient work owing to the fact that they would need to travel shorter distances to their places of business, and the diminished danger of illness. Arrangements by which employees who intend to remain permanently in the service could purchase their houses on long terms would probably be extremely advisable.

THE RELATION OF THE LABORATORY TO THE GENERAL HOSPITAL.

Modern medical science has advanced to the point where intelligent hospital practice is impossible without the complete cooperation of a well-equipped laboratory; and, conversely, productive research is not possible to a biological laboratory without the intelligent cooperation of a hospital. For this reason the superintendent of government laboratories has repeatedly urged that a general hospital, when established, should be placed in close proximity to the laboratory buildings, and it is gratifying to perceive that this view has finally come to be the one adopted by the general hospital committee. The ground on which the laboratories are situated belongs to the government. It is ample for the purposes of the laboratory building, the wings for the various other scientific bureaus, a general hospital, a medical school, a home for nurses, and probably other structures as well. The situation is a good one, and the ultimate relationship brought about by such a group of buildings will be ideal.

Progress in the laboratory in the past has been satisfactory, but many important problems are yet unsettled; the proper solutions of them depend upon careful and well conducted research. In the future, as well as in the past, the liberal support of such work will be a matter of financial economy to the insular government.

I am, very respectfully,

PAUL C. FREER,
Superintendent of Government Laboratories.

THE SECRETARY OF THE INTERIOR,
Manila, P. I.

EXHIBIT A.

REPORT OF THE DIRECTOR OF THE SERUM LABORATORY, DR. JAMES W. JOBLING, COVERING THE PERIOD FROM JANUARY 1, 1903, TO AUGUST 31, 1903.

During the first part of the fiscal year, and while this laboratory was under the control of the board of health, my health had suffered from the effects of overwork and the debilitating climate, and I was given two months' leave of absence with permission to visit Japan. This time was spent studying the methods of preparation of serums and prophylactics used by Professor Kitasato in the Government laboratories, Tokyo, Japan.

I can not speak too highly of the kindness shown me by Professor Kitasato and his assistants during my stay with them, every facility and assistance being put at my disposal. During the most of this period I was making a study of the production of antiplague serum, it being one of the most important diseases with which we were then contending in Manila.

Rinderpest having suddenly become epidemic in the city of Manila, Doctors Strong and Musgrave began the preparation or antirinderpest serum, and at the time of the return of the director a considerable quantity of this material was on hand.

Rinderpest having been reported on the island of Tablas, Veterinary Surgeon John G. Slee and Assistant Director Charles S. Sly, with 4½ liters of serum, were sent to the island to inoculate all the cattle and carabaos in the surrounding barrios by the "simultaneous method" and to treat those animals already sick with large doses of serum. A detailed report of the work done by them will be given under the heading of "Rinderpest inoculations."

Toward the latter part of October, 1902, all rinderpest work was stopped by the development of foot-and-mouth disease among the serum animals, which of course prevented their further use until they had completely recovered.

One experience convinced us of the impracticability of doing much work as long as foot-and-mouth disease was present in the laboratory. The serum animals having recovered, five nonimmune animals were purchased to obtain virulent blood for further inoculations. They were placed on a portion of the laboratory grounds which it was thought had not been previously infected either with foot-and-mouth disease or rinderpest, but we were very quickly undeceived. On the second day all developed foot-and-mouth disease, and on the fifth rinderpest. The combination proved fatal, as all the animals died in a few days—in fact sooner than we have ever seen animals die which had contracted rinderpest alone.

Because of this experience a quarantine stable was erected in which all animals could be placed under observation for a sufficient number of days to prove the absence of foot-and-mouth disease or to effect its cure, so that all danger of a subsequent development would be reduced to a minimum. The grass within a radius of 15 feet of this stable was removed, enabling us to thoroughly disinfect the ground in its vicinity. The excreta were disinfected with crude carbolic acid and lime, and the entire building whitewashed with a solution composed of lime and carbolic acid. This was repeated every time an animal was removed from the stable. Finding it to be impossible to have the native attendants take the proper precautions so as to prevent the transfer of the infection to the remainder of the grounds, mats kept wet with carbolic acid solution were placed at each gate. These were sufficiently large so as to make it almost impossible to pass through the gate without disinfecting the feet or shoes, but in addition everyone passing from one lot to another was directed to thoroughly cleanse his feet upon these mats.

In the beginning the virulent blood of those animals having both rinderpest and foot-and-mouth disease was not used for inoculating the serum animals, but after experimenting on several and finding no bad effects to be produced we ceased paying any attention to the combination when it occurred in an animal having rinderpest. Not many animals with the combination of infections were used, so it is impossible to state whether the absence of bad results following these inoculations was due to an immunity following a previous attack. It was known that a number of the old serum animals had recovered from the disease and were thus at least partially immune, but there were on hand several bullocks which were not at the laboratory during our epidemic, and their hoofs did not show the corrugations usually found on the recovered animals.

On January 1, 1903, this laboratory was transferred from the board of health to the bureau of government laboratories. At this time the laboratory equipment was very incomplete, a large list of apparatus having been ordered but not received until later.

The work has been greatly retarded by lack of assistance and became still more so when Asst. Director Charles S. Sly was ordered to Shanghai on April 26 to supervise the prophylactic inoculation against rinderpest of carabaos which the government is purchasing at that point. In a great many instances the force was found to be greatly insufficient, a large amount of work which should have been done being left untouched. This applies more especially to the preparation of other serums, some of which we were compelled to order from Japan.

Again, the fact that our present location is but temporary, so as to make any very expensive improvements inexpedient except on permanent grounds, was an impediment, as it prevented us from making certain improvements which would greatly have facilitated the work.

RINDERPEST SERUM.

As stated previously, this work was started in September, 1902, while the director was in Japan, by Doctors Strong and Musgrave. A description of the preparation of this serum is given in the accompanying circular, entitled "A preliminary report on the study of rinderpest of cattle and carabao in the Philippine Islands," as follows:

This preliminary report is especially intended as a circular of information to the cattle shippers and breeders of the Philippine Islands, giving them the symptoms, means of prevention, and treatment of rinderpest, and, as a consequence, scientific discussion and technical terms have been avoided wherever possible. The civil government intends to immunize all the cattle and carabao now on these islands, as well as those to be imported. To accomplish the best results, it is necessary for cattle shippers and breeders to become thoroughly acquainted with the disease in order to successfully cooperate in the work.

In the following, articles written by numerous authors have been consulted and free extracts made.

Definition.—According to Gamgee, "Rinderpest is a specific, malignant, and highly contagious disease, known to us only as the result of direct or indirect communication from sick to healthy animals. It never originates spontaneously, but is perpetuated by constant reproduction, after the manner of other contagious diseases. It is essentially a bovine disease, although it is claimed it may be communicated to swine, goats, sheep, deer, antelopes, gazelles, and zebras, seldom attacking any animal more than once." My own definition would be that it is a specific, infectious disease, characterized by congestion and inflammation of the mucous membranes, more particularly of the digestive tract.

It is marked by a period of incubation of from three to ten days; by fever, which precedes all other symptoms; redness of all the visible mucous membranes, seen early and in a marked manner in the vagina of cows; sometimes delirium and muscular twitching; discharges from the eyes and nose; normal secretions checked or suppressed; abdominal pain with diarrhea, although in certain instances there may be constipation. In some epidemics a scaly eruption on the back and loins and a characteristic one on the inside of the thighs and on the mammæ, together with fetor of the breath and discharges are observed. The majority of animals seized with rinderpest die, and, after death, decomposition rapidly takes place.

The following brief historical retrospect is taken from an extract of Fleming's work on Animal Plagues, and Gamgee's work on Cattle Plague, as given by Edington in his annual report to the colonial secretary, Cape Town, for the year 1897.

The date of the first account of a disease among cattle, which probably was rinderpest, is given as A. D. 69. Columella, who lived at that time, and who, according to accounts, had considerable influence on the progress of veterinary medicine, has written of many of the diseases of the lower animals. In the ninth chapter of the sixth book, in describing the symptoms of the fever, he says:

"The fever is present when the tears are running down the face; when the head is carried low and heavily, and the eyes are closed; when the saliva flows from the mouth; when the respiration is shorter than in health and seemingly embarrassed, or sometimes accompanied by groaning."

He further insisted on the most sensible procedure of separating the sick from the healthy stock.

Since that time epidemics of greater or less extent have from time to time attacked the cattle on large areas of the globe.

Rinderpest has caused the death of several million cattle in Europe alone. In A. D. 360, eastern Europe was visited by an epidemic of an exceedingly virulent character, which caused an enormous loss, the cattle apparently dying almost as soon as they became sick; in A. D. 591 Italy, France, and Belgium developed a scourge which left scarcely sufficient cattle to breed from; in the year 694 England suffered from an epidemic which caused untold suffering, and during the year 801 France was again severely afflicted.

From this period up to the beginning of the eighteenth century, when our knowledge of epizootic diseases becomes more exact, numerous epidemics of a virulent disease appeared among cattle in all parts of Europe, causing immense loss and great suffering.

In 1708 Kanold asserts that rinderpest had commenced its destruction in Russia, from which country it spread to all parts of Europe. Of all the descriptions of this epidemic relating to the nature and spread of the cattle plague, probably the best are those of Lancisi and Ramazzinni, two physicians who gave special attention to the disease. Their description of the symptoms corresponds with those encountered in the Philippine Islands with this exception: I have never seen, either at this laboratory, where the animals have contracted the disease by means of natural infection and by inoculation, or in the provinces, where the disease is contracted by natural infection alone, cases covered with pustules and small tumors. From the frequency of the pustules in the cases observed by Lancisi and Ramazzinni, they concluded that the disease was similar to and identical with smallpox in man.

In Holland, during the year 1713, 200,000 animals are supposed to have succumbed to the disease, and between 1711 and 1714 over 1,500,000 died in western Europe; in the interval between 1840 and 1843 Egypt lost over 665,000; in 1865, 500,000 were destroyed in England, and from 1884 to 1894 Russia lost over 1,815,000.

The disease is now present in India, China, Africa, the western part of Russia, and is said to be endemic in the Balkans.

In the Philippine Islands rinderpest apparently first appeared in 1882, when the Spanish Government issued a pamphlet instructing the people in methods of diagnosis and treatment, and from this period until the present time it has extended to most of the islands of the archipelago, causing a loss of many of the cattle and carabao, estimated by some to be as high as 90 per cent.

METHODS OF TRANSMISSION.

The cause of rinderpest is not known, but from its being so very infectious, and from the fact that it is so easily conveyed by the blood, it is probably produced by some microorganism the nature of which we have been unable to determine. The infection is carried but a very limited distance in the atmosphere or by running water. The usual method of transmission is by means of infected ground, but it can also be conveyed by any of the excretions, such as the discharges from the nose and mouth, the stools, and, according to some authors, by the bile; by buckets and other objects which have been in contact with the sick animal; by means of the indiscriminate disposal of the offal or by allowing the excreta to pass by way of an open drain into or through a pasture containing healthy cattle; by means of men attending sick animals and carelessly carrying the infection upon their shoes to a place where healthy cattle are kept; by dogs or wild hogs, which, if allowed access to the carcass of an animal dead with rinderpest, may tear it to pieces and scatter the bones and fragments of flesh to new areas of ground, which thus become infected. It can also be conveyed by means of the hides removed from animals dying of rinderpest. One source of great loss to cattle shippers is in transporting cattle on ships which, without proper disinfection, have previously been transporting diseased animals.[a]

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[a] This latter danger has been shown conclusively during the work in this laboratory, where we are compelled to obtain our calves for vaccine virus and cows for the preparation of serum from China. With but very few exceptions every shipment of calves or cows we have received has either shown some of the first symptoms of the disease (high temperature) on admission or has developed the same within twenty-four hours.

One instance of this occurred very recently. Fifty calves were five days in transit from Hongkong to this port, and within seventy-two hours after admittance to this

In experimental work it has been proven that 0.1 c. c. of blood taken from a sick animal and injected under the skin of a healthy one is sufficient to reproduce the disease.

Edington states that if a small amount of the discharge from the nose of a sick animal be rubbed on the muzzle of a healthy one the latter will contract the disease almost as quickly as if it had been inoculated with virulent blood, but if this discharge be kept twenty-four hours before applying to the healthy animal the disease is greatly modified in type. He further mentions that in localities in which redwater or Texas fever was present, and where ne was afraid to inoculate with virulent blood for fear of conveying the Texas fever parasite, he diluted the blood with a large quantity of water and drenched the animal with it. In these cases they contracted the disease about as quickly as when inoculated. In a series of experiments, made in order to find out the maximum length of time rinderpest would live in the dried state, he added sufficient blood to dry sawdust to give it a bright-red color and allowed the mixture to stand at room temperature for six days. He found that 2 grams of this mixture would produce the virulent disease.

Hutcheon states that complete desiccation destroys the infection, and that putrefaction apparently has the same effect.

From the above it will be very readily seen what a great mistake it is to allow an animal sick with rinderpest to remain at large, with the subsequent danger of infecting all the remaining stock in the vicinity. If a few precautions were taken the danger would be reduced to a minimum.

GENERAL PATHOLOGICAL ANATOMY.

The body is emaciated. There is often an excoriation of the skin below the inner canthus of the eye, produced by the irritating discharge during life. The tail and buttocks are often soiled by the fecal discharges.

So far I have been unable to determine any specific cutaneous lesions, especially none of those reported by the older writers.

In one case (carabao), in which the animal was sick about twenty days, a pustular eruption appeared about the fifteenth day. This eruption was discrete, but the pustules were very close together and scattered over the entire surface of the body, apparently showing no predilection for any one part.

The natives in the provinces claim that many of the convalescent animals show a scaly appearance of the skin, but we have never noticed this condition in a sufficient number of cases to be able to say that it generally accompanies the disease.

The skin covering the upper lip is often thickened and excoriated by the discharge from the nose.

The conjunctivæ are nearly always congested, more especially in carabaos, in which animals they are generally a bright-red color. I have seen a number of cows sick with rinderpest, where the conjunctive showed practically no changes. These cases generally occurred in animals which had been inoculated with the disease.

The mucous membrane of the nose generally, and over the septum in particular, is deeply congested. It often appears of a purple color. In a few cases I have noticed superficial ulcerations on the anterior portion of the septum, but I am inclined to think that they were due to some other cause.

Most writers upon rinderpest lay stress upon the frequency with which ulcers are to be found in the mouth. This is contrary to our experience at this laboratory, for while the great majority show a marked congestion of the mucous membrane, with a covering of thick, slimy mucus, comparatively few show ulcerations.

Ulcers sometimes appear on the dorsum of the tongue, accompanied with marked congestion.

The fauces and pharynx are the seat of a catarrhal inflammation and covered with thickened mucus.

Edington states that in many of his cases the tonsils showed pin-head abscesses in the cortical layer.

The mucous membrane of the œsophagus and trachea, as well as in other parts of the body, may be deeply congested, but in the majority of cases appears normal.

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laboratory for immunization 20 were dead. In this case 2 died within twenty-four hours after admission, while, with the exception of 4, all showed a temperature of 41° C. or over.

As the incubation period of rinderpest is from three to ten days it can be seen that the infection must have taken place either aboard the ship or in Hongkong just previous to shipping, as after arriving at the laboratory the majority died before they had passed the regular incubation period, whereas if the infection had taken place here the animals would hardly have shown serious symptoms before eight or ten days.

The lungs generally appear perfectly healthy. In some cases there is a congestion, but I believe this to be principally hypostatic, due to weakened heart action. A number of cases showed an emphysematous[a] condition.

The pericardium contains about the usual amount of fluid and appears normal. The parietal lining sometimes shows a few subserous hemorrhages.

It is not uncommon to find petechiæ (minute dark-red points) scattered over the surface of the heart.

The muscular tissue is generally paler than normal, and shows a condition of of marked cloudy swelling. In the cavities of the heart the blood seldom coagulates firmly, either forming a soft coagulum or having a sirupy consistence. The endocardium or lining membrane often shows minute hemorrhages.

The general lymphatic system seems to be affected in this disease, as in the majority of cases almost all of the lymphatic glands of the body appear enlarged, and in some cases present an edematous appearance. This condition is best seen in the abdominal cavity, where the glands in the mesentery supporting the small intestine are almost invariably greatly enlarged, and in some cases hemorrhagic.

The rumen (first stomach), the reticulum (second stomach), and omasum (third stomach) are generally normal in appearance, although the contents of the last are always very dry and the mucous membrane sometimes slightly congested.

The abomasum (fourth stomach) is usually the organ in which the most marked pathological changes are found. The contents are generally fluid, and consist of a large amount of mucus and often of considerably blood mixed with the food. The odor is very foul.

The changes in the mucous membrane vary from a slight congestion, generally localized at the pyloric or lower end, to an extreme one with ulcerations, involving the mucous membrane of the entire organ.

Very often minute hemorrhages about the size of a pin head will be found over the deeply congested areas. Numerous small ulcers are often present, more often at the pyloric or lower end. They are generally shallow, with the bottoms covered by a greyish-yellow exudate. I have seen cases in which the ulcer extended completely around the pyloric orifice.

The upper portion of the small intestine is invariably congested, almost to as great an extent as is the fourth stomach, and it often shows the minute hemorrhages so frequently observed in the latter. I have never seen more than two or three cases in which there were ulcerations in this location; these are apparently confined to the fourth stomach and cæcum.

In the severest form of the disease, the feces show casts from 12 to 35 centimeters in length and post-mortem examination demonstrates a diptheritic condition of the upper portion of the small intestine with pseudo-membraneous formation.

In many cases the mucous membrane of the remainder of the intestine is so slightly affected as to appear normal, while in others there is the most extreme congestion, with the formation of casts. Peyers patches are often enlarged, but, in my experience, never ulcerated. I have never seen ulcers in this portion of the intestine. A marked congestion is very often seen around the ileo-cæcal valve, with small submucous extravasations of blood.

The cæcum is generally merely the seat of a congestion, but in other cases it is violently inflamed, showing ulcerations, hemorrhages, etc.

The colon is frequently congested, but the changes are not so far advanced as those seen in the upper part of the small intestine and in the fourth stomach.

The peritoneum often shows signs of an acute localized inflammation, involving that portion covering the small intestine, which is often coated with a fibrous exudate.

The peritoneal cavity usually contains a larger amount of fluid than is found in a healthy animal.

The liver is greatly congested, often presenting a mottled appearance, and shows evidence of marked cloudy swelling. It is frequently bile-stained.

The gall bladder is distended with bile, which is usually green in color, but I have seen all shades, from a light yellow to black. The mucous membrane usually appears healthy, but sometimes is markedly congested, covered with a tenacious mucus and showing the petechia or pin-head hemorrhages described above as occurring in the fourth stomach and elsewhere.

The kidneys are congested, in some cases showing numerous petechia scattered over the capsule of the organ.

The surface of the spleen appears of a slate color and wrinkled. The organ does not appear to be greatly congested and is about normal in size.

The vagina is always greatly congested.

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[a] Dilated air cells in the lungs.

The mucous membrane of the bladder, like that of other portions of the body, may be deeply congested, but is usually normal. Some cases present a hemorrhagic appearance.

SYMPTOMS.

Our observation of rinderpest resulting from natural infection has been almost entirely confined to the disease occurring in animals which have contracted it previous to their admission to this laboratory, but which have shown the first symptoms two or three days afterwards, and to that developed by individuals which have been put on a small area of ground, previously infected by the excreta and discharges of animals dying of rinderpest. The animals were tied to stakes which had been driven into the ground in the center of the infected paddock, and their food was placed in such a position as to mix it more or less with the infected excreta.

The incubation period in those animals contracting the disease from this exposure varied within a range of from six to ten days. In no case have I seen it less than six days. The earliest rise of temperature observed is about fifty-one hours after inoculation with nasal mucus (Edington).

In animals inoculated with virulent blood the incubation period is from sixty to ninety-six hours. The rapidity of onset and sometimes the intensity of the subsequent disease depending, first, upon the virulence of the disease in the animal from which the blood was obtained; second, upon the length of time the latter has been kept, and third, upon the quantity used for the inoculation. The average time before the first rise of temperature is about seventy-two hours. In case the animal is inoculated with a large dose (10 c. c. to 25 c. c.) a rise of temperature is often noticed on the evening of the same day, but the temperature generally falls to normal on the following morning and remains so until the period of incubation has passed.

Generally on the evening of the fourth day after inoculation a rise in temperature to 40 to 40.6 C. will be noted.[a] It does not remain high in all cases, but sometimes drops to normal on the following morning, remaining so for twenty-four hours and then again rising to over 40° C., remaining high, with slight morning remissions until just before death, when it rapidly drops to subnormal.

The temperature curve in an inoculated animal is well shown in Chart No. 1.

Chart No. 1.

Cow No. 45, November 12, 1902.

[Weight, 400 pounds; age, 2 years; sex, female; color, light brown; inoculation, rinderpest; history, inoculated November 14, 1902, with 5 c. c. virulent blood from calf No. 56.]

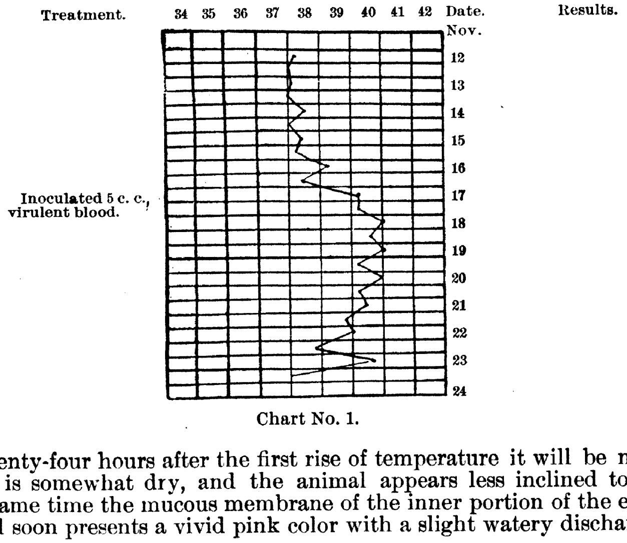

Chart No. 1.

About twenty-four hours after the first rise of temperature it will be noticed that the muzzle is somewhat dry, and the animal appears less inclined to take food. About the same time the mucous membrane of the inner portion of the eye becomes injected and soon presents a vivid pink color with a slight watery discharge running

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[a] In the Philippine Islands a healthy cow's evening temperature will average about 39° C.

SERUM LABORATORY.

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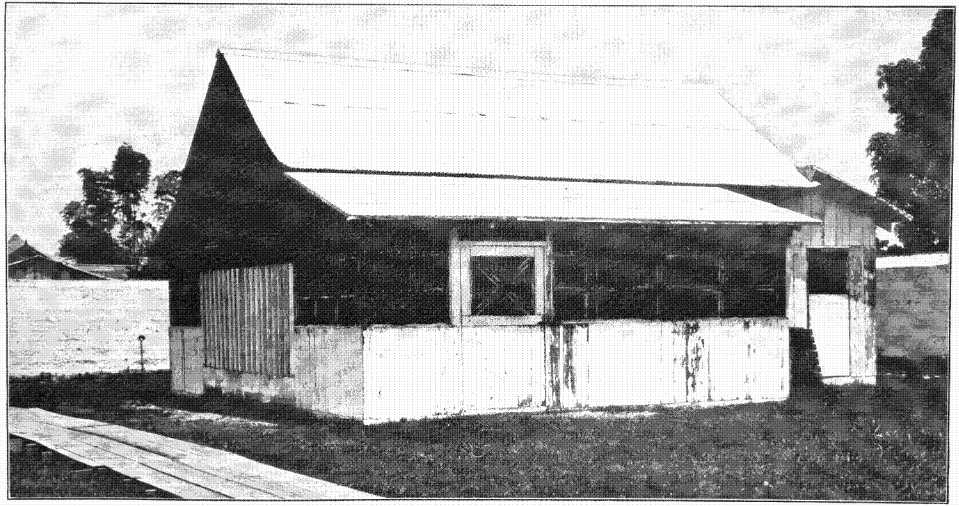

FLY-PROOF STABLE AT SERUM LABORATORY.

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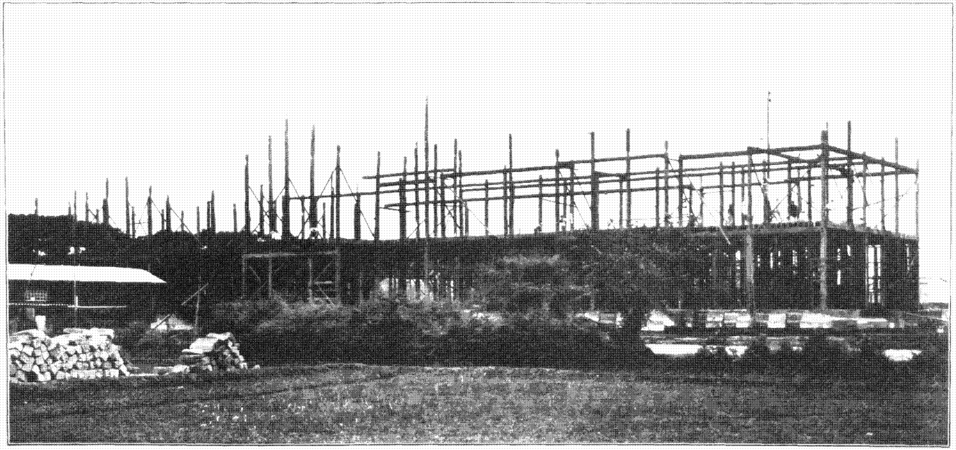
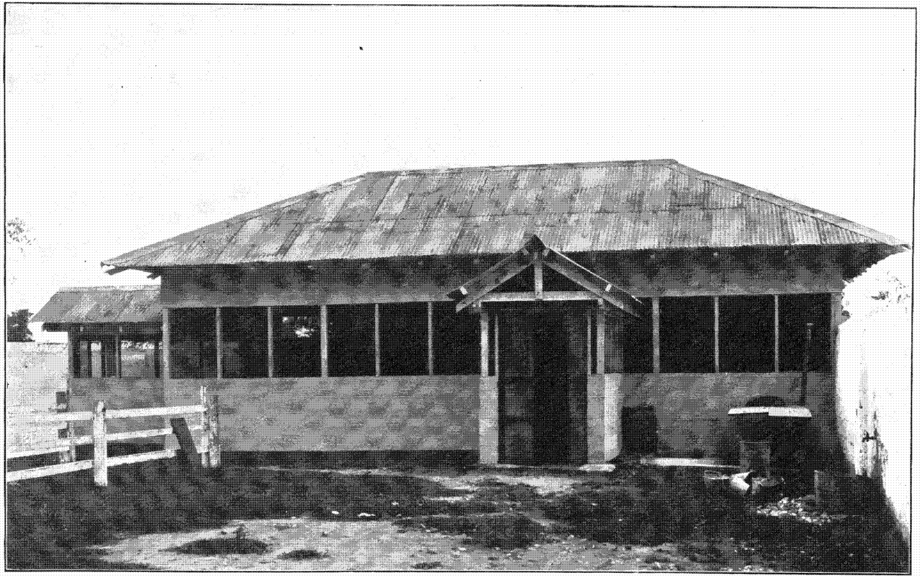


NEW LABORATORY BUILDING UNDER CONSTRUCTION



OPERATING ROOM AT SERUM LABORATORY.

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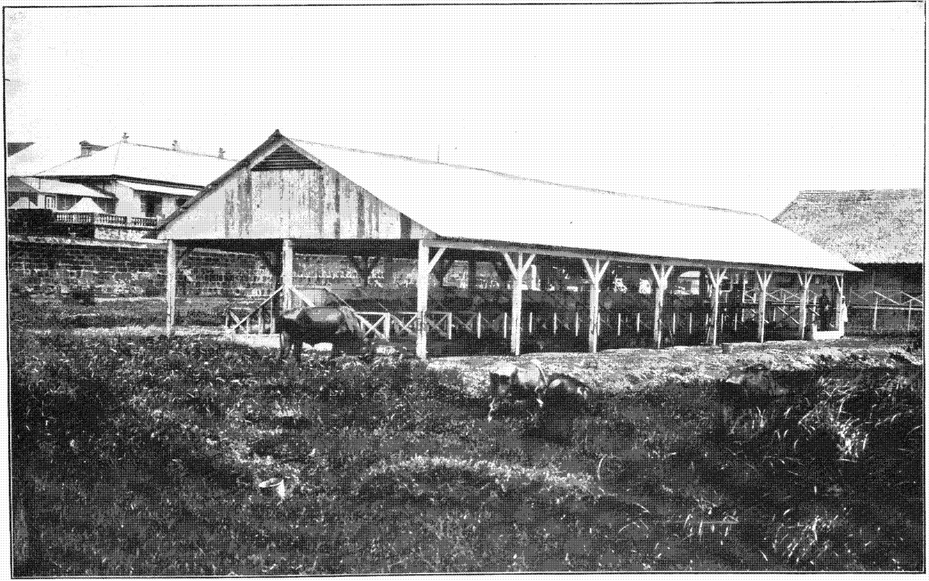

CATTLE QUARANTINE STATION AT SERUM LABORATORY.

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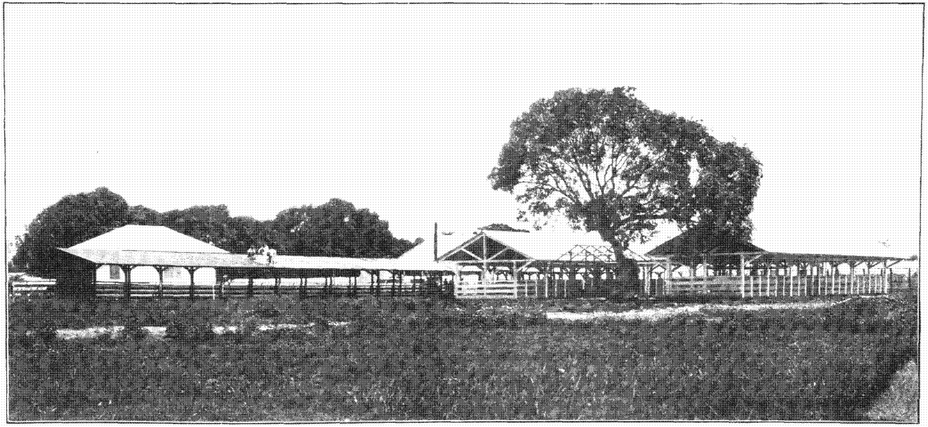
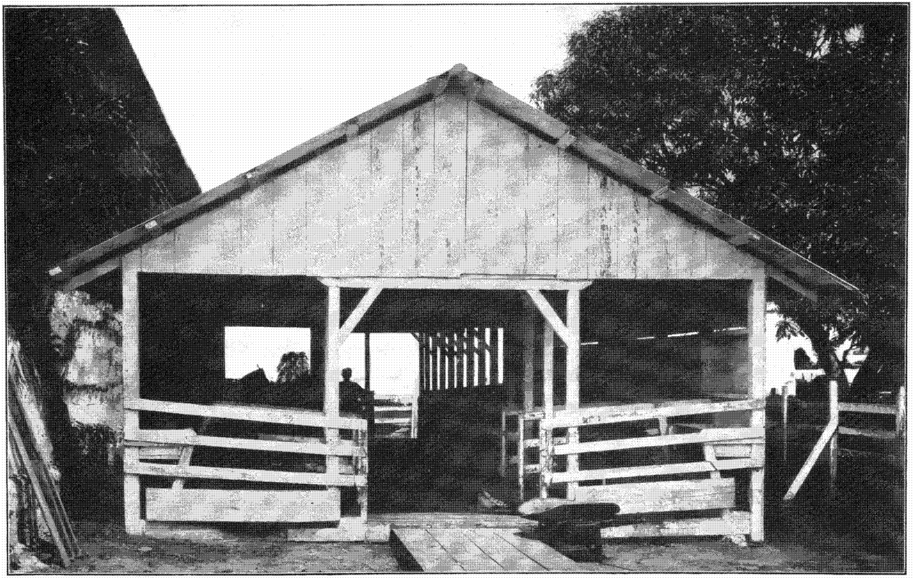


SHEDS AT SERUM LABORATORY.



DETENTION STALL FOR CALVES, SERUM LABORATORY.

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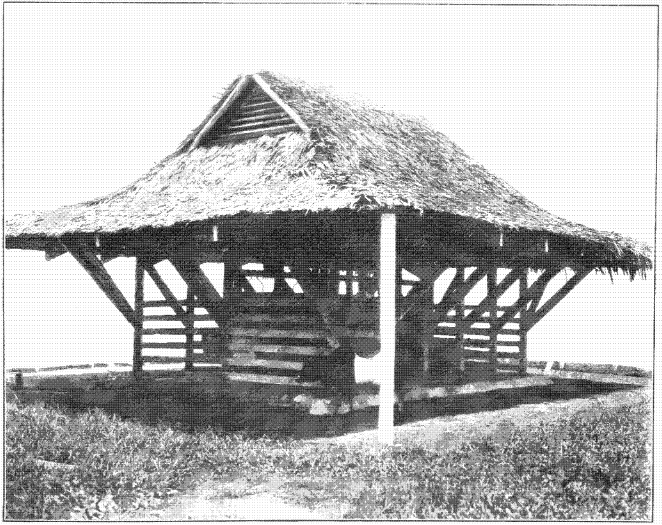

STABLE FOR VACCINE CALVES WITH SUN SHELTER.

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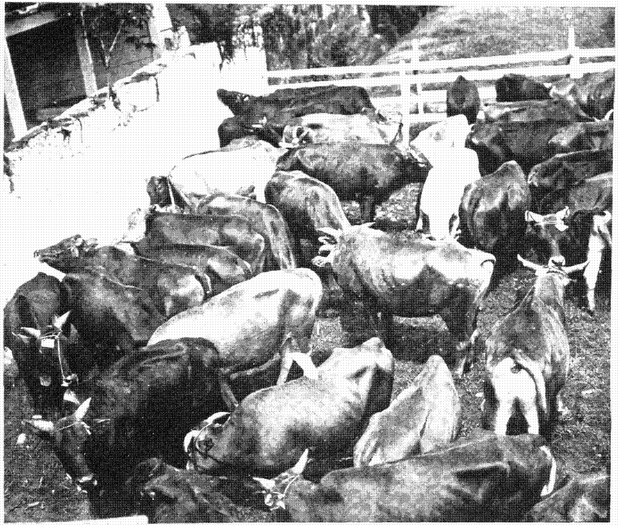

FIG. 6.—CATTLE USED IN PREPARING ANTIRINDERPEST SERUM AT SERUM LABORATORY.

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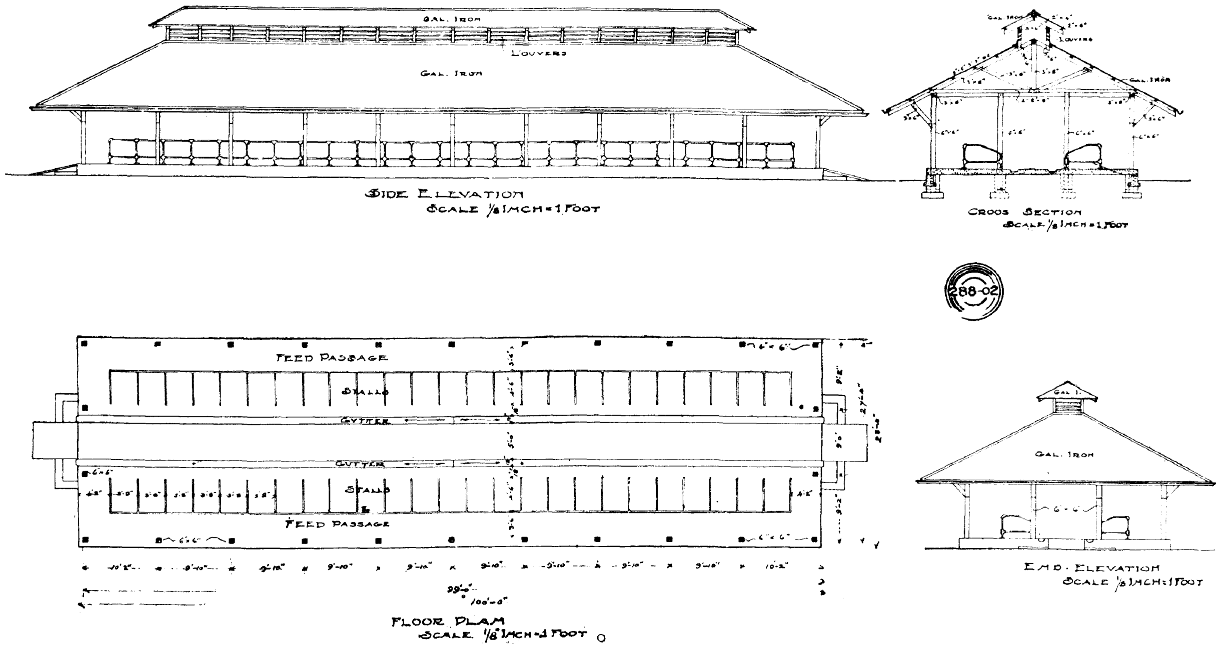
CATTLE STABLE for SERUM LABORATORY
BUREAU of GOV. LABORATORIES



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down the face from this point. In many instances this is the initial visible symptom of the disease. The mucus discharge from the nose is much augmented. The bowels are somewhat constipated, although the feces are often coated with slimy mucus. The hair is rough.

The animal shows great thirst; and if in the open, leaves the herd; and, if water is near, will stay by it; the ears hang forward; the head droops, while flies gather about it and no great effort is made to dislodge them. There may be twitching of the superficial muscles of the back, shoulders, or hind quarters; rumination is irregular or ceases, grinding of the teeth becomes almost constant. When the animal is lying down the head is commonly turned toward the flank. With the exception of those cases noted above, the temperature at this time is very high, in many cases being over 41° C.

About forty-eight hours after the first rise of temperature the hardened feces give place either to a foul-smelling, discolored watery discharge containing mucus flakes and blood, or to a dirty, thick, slimy fluid containing streaks of blood, and in some cases mucus casts. The other symptoms now all become aggravated. The discharges from the eyes, nose, and mouth are increased in amount, that from the nose is changed in character, being now thick and muco-purulent, while the skin of the upper lip over which the secretions have been running becomes thickened, dry, and excoriated. The breath has a very offensive odor. Prostration is very great; the animal while standing trembles from weakness; there is extreme thirst. It soon lies down, moaning; the liquid feces are passed almost continually with great straining, finally involuntarily, the animal groaning from the tenesmus. It rapidly becomes weaker, the respirations are more rapid and labored; finally, just before death, the temperature drops to subnormal.

The symptoms described above are not constant, either in the order given, character, or severity.

The duration of the disease from the first rise of temperature until death is usually from two to ten days, the average being about six.

If rinderpest is of a milder type, the stools after a few days lose the mucus and blood streaks, and gradually assume their normal consistency, all the other symptoms abating at the same time.

I have noticed that a larger percentage of carabaos than of cattle show the highly injected conjunctivæ, and that following the "simultaneous method" of inoculation, when a diarrhea does appear, it generally does so at an earlier stage with carabaos than with cattle.

The great majority of the animals which are affected die. Some authorities state that the mortality is from 60 to 80 per cent, but here in the Philippines I believe it to be much higher, especially in the rainy season. This is also noticed by the natives, who maintain that while in the wet season most of the animals die, in the dry season many recover.

In this respect it is interesting to note that in regions where wild hogs are numerous the natives state that they find dead hogs as the epidemic rises in extent and virulence. They explain this by the theory that the wild hog contracts the disease while eating the carcasses of animals dead with rinderpest. In the Pasteur Institute it has been found that hogs are susceptible to the disease, and in view of this the above does not seem improbable.

In this laboratory we have had no opportunity to experiment with wild hogs, but procured two farm-bred animals, one of which was inoculated with 5 c. c. of virulent blood. The animal appeared dull on the day after, had very little appetite, and was lying down most of the time, with no other symptoms. The temperature on the evening of inoculation was 39.5° C.

On the third day after the inoculation the animal showed distinct signs of illness, the back was arched; head hanging; no appetite; extreme thirst; conjunctivæ slightly congested, with a discharge from the inner angle of the eye; the hog lying down most of the time. The respiration was rapid. The morning temperature was 40.2° C., and the evening 40.4° C.

On the fourth day there was a profuse yellowish, watery diarrhea, the animal appearing to have involuntary discharges part of the time.

There was no mucus or blood in the feces at any time. With the exception of the diarrhea, the animal showed the symptoms it did on the previous day, although it was now weaker.

On the fifth day the diarrhea had disappeared; the animal was still very weak, but the temperature had dropped to normal. The hog was now bled to death, the blood being drawn into potassium citrate solution and used to inoculate hog No. 2 and cow No. 46.

The post-mortem showed no marked lesions, with the exception of a slight hyperæmia of almost the entire alimentary canal.

Hog No. 2 received 5 c. c. of the blood, but never developed any symptoms of the disease.

Cow No. 46 received 7 c. c. of the blood and, after the usual incubation period, showed the typical form of rinderpest, although the symptoms were much milder than is generally seen after inoculation with such a large quantity of virulent blood. Unfortunately no other nonimmune cattle were on hand to test the blood drawn from this cow, so that further experiments were prevented. This animal was bled to death. The post-mortem lesions were those usually seen in rinderpest, although not so far advanced.

This hog had the shortest incubation period of any animal I have seen, and I would have believed it to be suffering from some other disease had cow No. 46 not developed typical rinderpest after the regular incubation period.

From this one series of experiments it would appear that while the hog may contract the disease and die, and its excreta may form a source of infection for cattle and carabao, yet it is difficult for the sick hog to reinfect others of its kind. However, no definite conclusions could be based upon the evidence at my disposal, and the work will be continued when opportunity offers.

Some experiments are now being conducted in the provinces to determine the susceptibility of the wild hogs, and to see if they are able to communicate the disease to others.

PREVENTIVE MEASURES.

When an animal shows any symptoms of the disease as hereinbefore described, it should be immediately isolated. By isolation I mean that it should be entirely separated from the remainder of the herd and placed on a small inclosed area, so situated that after it dies or recovers the ground and everything which has come in contact with it can be thoroughly disinfected. It could be kept on the spot where found, temporarily fenced in, and with a bamboo and nipa covering to protect it from the rays of the sun. The excreta should not be allowed to enter a drain and so infect surrounding territory, but should be retained on the spot and thoroughly disinfected either with crude carbolic acid in a strength of about 3 per cent, or by the addition of good chloride of lime, or buried. The attendant, if a native and not wearing shoes, should thoroughly disinfect his feet as well as his hands with a per cent solution of carbolic acid before coming in contact with other animals.

If he wears shoes, he should have two pairs, one to wear while working with the sick animal, the other (which should be left on the outside of the inclosure) to be put on when leaving.

After the animal dies or recovers, the shelter should be burned on the infected area, and the entire surface of ground within the inclosure, as well as that on which the animal has been browsing or lying, disinfected with carbolic acid or chloride of lime. It would be still better, after sprinkling with carbolic acid or chloride of lime, to cover the ground with dry grass and then set fire to it.

The remainder of the herd must be transferred to new pastures and there kept separate from one another, and the temperatures of all taken daily. Any animal showing a temperature above normal, or any of the symptoms described, should be immediately isolated in the manner above described, and the herd once more moved.

By following these precautions I believe an epidemic of rinderpest can be suppressed in its beginning, and only those animals which are in the incubation stage at the time the disease is first recognized will further develop the disease.

The bodies of the animals which have died of the disease should be either burned or buried. It is better to burn them; but if this can not be done, care should be taken to bury them so deeply that hogs and other animals can not exhume them and scatter the bones and fragments of flesh around the surrounding country, in which event new points of infection would probably be formed.

A very careful search should be made for the source of the primary infection, so that after suppressing the disease in the herd it may not be reintroduced.

As the hides removed from animals dying of rinderpest convey the disease, they should be thoroughly disinfected with a 1 per cent solution of carbolic acid, allowing them to remain in this solution for several hours, and then hanging them in the hot sun until thoroughly dry, turning them over several times so that the rays of the sun will strike all parts. If they are to be sent from the infected locality, it would be better to redisinfect them before shipment. I have given directions for the disinfection of the hides because their retention may be insisted upon. My own opinion, however, is that it would be better to destroy them with the carcass.

IMMUNIZATION.

There are a number of different methods of immunizing cattle and carabaos against rinderpest, several of which will be described, with their advantages and disadvantages.

INOCULATION BY A MIXTURE OF GLYCERIN AND BILE TAKEN FROM AN ANIMAL SICK WITH RINDERPEST (EDINGTON'S METHOD).

Edington recommends the use of bile taken from an animal which has been sick six days, preferably from one which has contracted the disease by natural infection, because he found greater immunity conferred thereby than by that taken from animals inoculated with virulent blood.

The bile, according to his directions, should be green, having a white froth on the surface and possess no putrefactive odor. To obtain it, open the abdominal cavity of the dead animal, tie the neck of the gall bladder with two strong ligatures of twine and cut between them. The bile can then be secured by one of several methods, viz, immerse the bladder in a bucket of 2 per cent carbolic acid, then wash in cool water which has recently been boiled, and open the bladder with a knife which has also been boiled, allowing the bile to flow into a vessel recently sterilized by thoroughly washing with boiling water; or, after the bladder has been disinfected, the bile can then be obtained by means of a trocar and canula, hollow needle, or even a sharpened small piece of bamboo which has been sterilized. If found to be satisfactory, half its volume of glycerin is added to the bile, and the mixture is then kept in a cool place for eight days; after which it is ready for use. The inoculator should not take the bile from the dead cow, as he is liable to carry the infection to the animals he is inoculating.

Of the bile thus prepared, 15 to 30 c. c. is injected under the skin of the dew-lap. The syringe which is used for this purpose should be allowed to remain in a 3 per cent solution of carbolic acid for about thirty minutes, and before using should be washed out with water which has been freshly boiled. It would also be well to wash the skin where the inoculation is to be made with the same carbolic-acid solution. After ten days the animal should be reinoculated with 0.2 c. c. of virulent blood.

The advantages of this method are: First, there are practically no deaths following the inoculation; second, after preparing the bile it can be kept ready for use for about one year; third, pregnant animals seldom abort.

The disadvantages are: First, the immunity thus produced lasts a very short time, generally from two weeks to three months; second, very little immunity is conferred until after ten days; third, in some animals no immunity is produced at all; fourth, the small quantity of bile secured from each animal makes it necessary to allow a number of animals to contract the disease in order to obtain a sufficient amount for the immunization of the remainder of the herd; fifth, it requires two inoculations; sixth, it is necessary to bleed a sick cow to get virulent blood for the second inoculation.

SERUM METHOD.

Koch demonstrated that the serum of the blood taken from an animal which had suffered from rinderpest and recovered possessed immunizing powers.

The serum which is used for this and the following methods is prepared by inoculating cattle with gradually increasing doses of blood taken from an animal sick with the disease, until they can bear very large quantities.

The animal first receives the "simultaneous method" of inoculation hereinafter described. If it shows a good reaction, i.e., rise of temperature after the proper period, it is given 100 c. c. of virulent blood after the temperature again drops to normal. This is subsequently, and under the same circumstances, followed by 500 c. c. and afterwards by 1,000 c. c.

If the animal does not show a good reaction within ten days after "simultaneous inoculation," it is given 10 c. c. of virulent blood. If a good reaction follows this dose, and after the temperature drops to normal, it received 250 c. c. of virulent blood, then ten days later (or after the temperature becomes normal) 500 c. c., and finally 1,000 c. c. After receiving a dose of 1,000 c. c. the animal is bled for serum.

In bleeding our serum animals, they are strapped upon the operating table, a small area over the jugular vein is shaved clean and sterilized with a 3 per cent solution of carbolic acid, followed by alcohol. The instruments are also sterilized in a 3 per cent carbolic-acid solution.

After sterilization is completed, a short incision is made over the course of the jugular vein. The latter being exposed, a trocar and canula are inserted into it. It is better, when the trocar is withdrawn, to attach a piece of rubber tubing to the canula, for if this is not done, the animal in its struggles may upset the vessel into which the blood is being drawn or cause the previously sterile vessel to become infected. The blood is allowed to flow into tall glass cylinders holding 500 c. c. each, about three liters being taken at one operation. It is then set aside for twenty-four hours, at the end of which time the clot will generally have contracted quite firmly and will be surrounded by the clear serum; this is drawn off by means of sterile pipettes or by a siphon.

After this operation the clots should be allowed to stand for an additional twenty-four hours, as at the end of that time some additional serum can be obtained.

Following Roger's plan, the animals, after receiving 1,000 c. c. of virulent blood, are allowed to remain until the temperature becomes normal. They are then bled three times with an interval of one week between each bleeding, after which they are inoculated with 1,500 c. c. of virulent blood and bled in the same manner as before. [a]

In using the serum, 50 to 100 c. c. should be injected under the skin, using the precautions given above.

The advantages of this method are: First, that it produces no reaction; second, in dairy cattle there is no suppression of milk; third, the immunity conferred is almost immediate; fourth, if the disease is just developing, it will often modify the attack, making it much milder in type; fifth, there are no deaths as a result of the inoculations; sixth, pregnant animals do not abort; seventh, the serum can be prepared in any quantity and it will keep during seven or eight months.

The disadvantages are: First, the short period of immunity, it averaging from two to four months; second, the skill required in preparing the serum; third, I believe sometimes very little immunity is conferred, as I have seen cases in which a small quantity of virulent blood, given from ten to fifteen days after the inoculation of serum, would develop a virulent type of the disease.

As stated above, a great many calves received from Hongkong for vaccine work have shown some of the first symptoms of the disease either upon the day of admission or within twenty-four hours thereafter. For this reason we have been giving all animals which have shown a temperature above normal, 50 c. c. of serum upon the day of admission, the remainder receiving the "simultaneous method" described below.

In these cases where serum alone is given, and where it is desired to confer permanent immunity, the calf is reinoculated with virulent blood alone after ten days. To obtain a reaction in these cases we have found it necessary to give a dose of 15 to 25 c. c. of virulent blood when it is given within ten to thirty days after the primary inoculation, and even under these circumstances some calves will show no reaction.

SERUM SIMULTANEOUS METHOD.

This method, with the modification noted on page 20, is the one in use at this laboratory, as well as at the principal points throughout the world where rinderpest is prevalent. It was first used by Kolle and Turner in their work in South Africa. It requires more skill than the bile method, as it is necessary to first prepare serum and then to obtain virulent blood from another animal sick with the disease.

When we first began inoculating in this laboratory we used fresh virulent blood, but soon found that Edington's method of preserving it, in a solution of potassium citrate to prevent coagulation, was preferable. If the blood is kept in a cool place it can, according to our experience, be used for at least seven days with good results. Some authors maintain that it can be preserved for a longer period. The blood is drawn into a 500 c. c. sterile flask, which contains 25 c. c. of a 5 per cent solution of potassium citrate, so as to give 1.25 grams of potassium citrate to each flask.

In using this method, the amount of serum necessary (which varies from 15 to 50 c. c., according to the susceptibility of the animal, as determined by experiment with others in the herd) is injected under the skin on one side of the animal, and 1 c. c.

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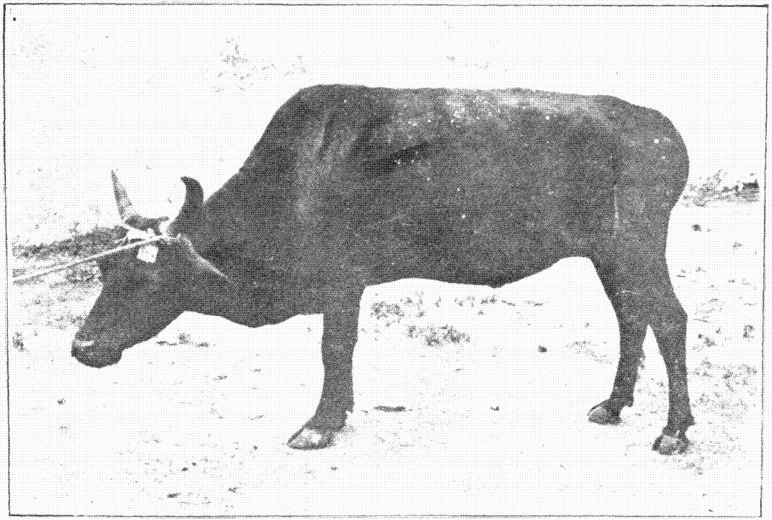
[a] My assistant, Mr. Chas. S. Sly, has had charge of the preparation and handling of all serums, while Dr. J. G. Slee, assistant veterinary surgeon to the city of Manila, has done nearly all of the bleeding, had charge of all the inoculations, as well as the general supervision of the stock on hand. A great deal of credit is due them for their valuable work in assisting in the suppression of the epidemic now prevalent in these islands. Their work has not been confined to this laboratory, but has extended to the provinces, where they have inoculated a great many cattle and carabao.



ANIMAL WITH RINDERPEST, SHOWING DROOPING EARS, FLIES SETTLED ON THE BACK, TAIL DRAWN IN, AND GENERAL DEPRESSION.

of the virulent blood on the opposite side and at the same time. If this amount of virulent blood were given without simultaneous inoculation of serum, it would invariably produce the disease in susceptible animals, but as the latter is given at the same time, it not only produces immediate partial immunity, but also aids the system in overcoming the toxic effects of the virulent blood; as a consequence a rise of temperature only is noted.

A temperature curve showing a good reaction after inoculation by the "simultaneous method" is shown in Chart No. 2.

CHART NO. 2.

Steer No. 72, December 31, 1902.

[Weight, 900 pounds; age, 4 years; sex, male; color, red; inoculation, rinderpest; history, inoculated December 31, 1902, with 1 c. c. virulent blood from cow No. 67, and serum 20 c. c.]

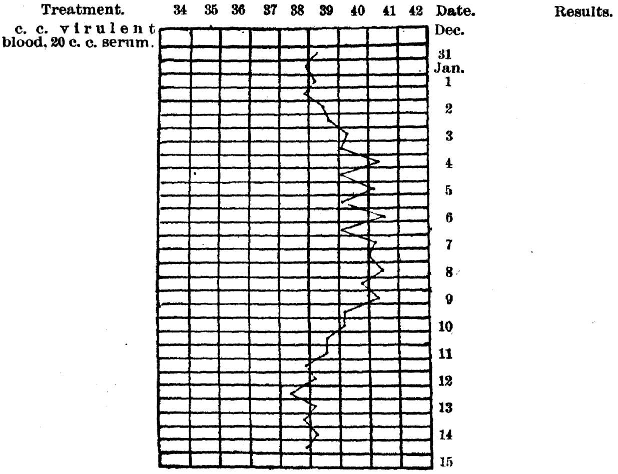


Chart No. 2.

The advantages of this method are: First, the serum can be prepared and kept on hand in large quantities; second, it confers immediate partial immunity, which becomes much greater after the resulting reaction, and if the animal is in the incubation period at the time of inoculation the subsequent disease may be modified; third, the reactions are more even, under better control, and the immunity lasts longer than by any bile method; fourth, only one inoculation is required; fifth, in animals showing a reaction the immunity conferred is very effective and lasts for years, while a temporary immunity probably lasting for several months is conferred upon the ones having no reaction.

The disadvantages are: First, the inability to perfectly control the reactions by the regulation of the relation between the dose of virulent blood and of serum; second, in order to obtain reactions in all animals, some cases require a second inoculation with virulent blood; third, to do the work properly it is necessary to take temperatures from the fourth day; fourth, the mortality, which is from 2 to 10 per cent, is higher than by any of the other methods described.

At this laboratory we use the simultaneous method as modified by Rogers. The modification consists in taking the temperatures on and after the fourth day of all the animals inoculated, and those showing no reaction from the first inoculation are reinoculated after ten days with 10 c. c. of virulent blood.

The advantages of this method are: First, a reaction is obtained more often than by any other method; second, it is shown in a much larger percentage of cases; third, those animals having no reaction after the second inoculation will have a longer immunity conferred upon them than by the serum or any of the bile methods, although it is probably not of long duration.

The disadvantages are: First, that second inoculations are required in some cases; second, beginning on the fourth day, it is necessary to keep temperature records of the animals, thus necessitating a larger force of inoculators; third, the difficulties encountered in the provinces where the natives are in such marked opposition to the inoculations as to render it almost impossible in the outlying districts.

This method is to be preferred when practicable, as immunity extending over a long period is conferred upon the majority of the animals, while a temporary one is given to all. Rogers states that after a good reaction the immunity continues for years.

The work done at this laboratory has been of too recent a date to determine the duration of the immunity in this country, but it will undoubtedly accord with Rogers's experience.

DEFIBRINATED-BLOOD METHOD.

This method originally recommended by Rogers may be used by cattle owners themselves.

It is first necessary to find an animal which has just recovered from the rinderpest; it is then bled, with all the precautions given on page 17, the blood being allowed to flow into a wide-mouthed vessel which has previously been sterilized. Then with an ordinary egg beater or wire brush which has been boiled for at least fifteen minutes, the blood should be whipped for fifteen or twenty minutes, or until there is complete separation of the fibrin, which forms a stringy mass clinging to the egg beater. The blood can then be used, as it will not coagulate; it is to be injected under the skin in doses of from 50 to 250 c. c. It must be used fresh, as it will soon spoil. It confers an immunity lasting from one to four months.

I believe that where the blood from a recently recovered animal is to be used for treatment or immunization, it would be better to draw the blood into a sterile flask or vessel containing the potassium-citrate solution. This would do away with the danger of contamination, which is often very difficult to prevent in the process of defibrination.

The advantages of this method are: First, it produces rapid immunity; second, the defibrinated blood is easily prepared on the field when animals which have recovered from the disease are present; third, there is no reactionary fever.

The disadvantages are: First, only a temporary immunity is obtained; second, the blood can not be kept; it must be fresh when used.

This method is one which should be of great benefit in distant provinces where it is impossible to obtain help or means for inoculation by the "simultaneous method." As immediate immunity is produced, it will be seen that with the exception of animals which already have the disease in its incubation period, no more will contract rinderpest during one to four months, the epidemic thus dying in its infancy.

TREATMENT.

Most of the writers whom we have been able to review, and who have had experience with rinderpest, join in saying that no treatment is of any benefit when once an animal has contracted the disease, although some state that large doses of serum given subcutaneously exert a favorable action upon the course of the disease.

Serum has been used in very large doses with infected animals in this laboratory, but, with the exception of two or three calves, we have been unable to detect any difference in the course of the disease, although a number of cases showed a transient fall in temperature. From the foregoing it is evident that prevention is the best treatment for rinderpest.

In case an epidemic breaks out in a locality the local health authorities should see that the infected animals are isolated, with all the precautions described on pages 14, etc.

The source of the primary infection should be traced if possible, and when found suitable precautions should be taken to prevent reinfection after the disease is under control.

Where possible all the animals in the infected district should be immunized by the "simultaneous method." When expert help can not be obtained for this purpose the "defibrinated-blood method" or "Edington's glycerin and bile" method may be used by the cattle owners themselves.

Of these two latter methods I believe the "defibrinated-blood method" to be the best, as immediate immunity is produced, whereas with the "bile method" it is first necessary to allow the mixture to stand eight days before inoculating animals, and full immunity is not conferred until ten days after inoculation, so that after the first case appears it is eighteen days before the animals become immune.

As no treatment has any effect upon the course of rinderpest, and as it has been proven that an animal which has been inoculated and has shown a good reaction seldom contracts the disease, it is evident that it is not only necessary to inoculate all the animals now in the Philippine Islands, but also those to be imported. By this means it will be possible to completely remove rinderpest from the islands, but if such precautions are not taken it will continue indefinitely, spreading from one point to another, killing off a large percentage of the young animals and so working a continual hardship on the people.

THE PROCURING OF VIRULENT BLOOD.

Our greatest difficulty lies in procuring nonimmune animals. Rinderpest has been prevalent in the Philippine Islands since 1882, and as it has passed over nearly all of the islands it can readily be seen that there is no certainty as to the results until after inoculating a native animal with a small dose of virulent blood. This inability to count on virulent blood just when it is needed for the serum animals seriously hampers the work. In some instances animals sick with rinderpest were procured from the corrals adjoining the abattoir, but as it was impossible to state just how long they had been infected they were only used in emergencies.

On numerous occasions animals purchased in Hongkong were tried, but as a certain number were found to be immune the expense was too great. Animals purchased in Cochin China were also experimented with, but the same trouble was experienced.

The most reliable animals purchased for this purpose were those from the island of Sibuyan, P. I. The natives say that rinderpest has never been epidemic on this island, but as the interisland boats are very irregular, especially to points on the island of Sibuyan, great difficulty even has been experienced in procuring these.

In the latter part of the fiscal year the work became more complicated by the presence of hemorrhagic septicemia, a number of cases developing in the government carabao shipped from Shanghai, while reports received from Hongkong stated that this disease is very prevalent in that locality. When hemorrhagic septicemia first appeared we were depending upon the development of rinderpest in animals from Hongkong for virulent blood to inoculate our serum animals, but this new complication necessitated a change in technique. We had previously been inoculating directly from the sick beast into the serum animal, which was kept in a stock near by, but after the development of the hemorrhagic septicemia the virulent blood was drawn into sterile flasks containing a 5 per cent solution of potassium citrate in such quantity as to give 5 per cent, or a sufficient amount to prevent clotting when the flask was filled. This procedure gives sufficient time to hold a post-mortem on the virulent blood animal before using its blood for inoculations. Where, on post-mortem, the animal showed any suspicious lesions, the blood was placed in the ice chest and cultures made from the different lymphatic glands and organs; if these were negative, it was used. While reports state that hemorrhagic septicemia is very prevalent in Hongkong, we have as yet seen but one case from that port.

This method of inoculating with virulent blood has not been in use a sufficient length of time to make any definite statement, but we believe that where the virulent blood is drawn into a citrate solution as described above and is then immediately used a stronger serum will be obtained. We are led to make this statement from observing the rapidity with which the blood is absorbed and from the more rapid and sharp reaction following the inoculation. In a great many instances where citrate was not used the blood clotting in the subcutaneous tissues would remain unabsorbed for a long time. In a number of instances the swellings induced by these injections were opened under the impression that they were abscesses and were then found to be large clots of blood which had apparently been walled off by the formation of fibrous tissue.

From this experience it would seem probable that any process which will prevent this change from taking place and at the same time hasten the absorbtion of the virulent blood will produce a sharper reaction and probably a stronger serum.

Difficulty in procuring nonimmune animals prevented our obtaining the dosage of our serum before using it in the provinces, as is recommended by Kolle and Turner, and so when starting the inoculation in any one province instructions were always given to take not more than ten animals, inoculating them by the "simultaneous method" with increasing doses of serum, changing from 20 to 25, 30, 35, and 40 c. c. The reaction to be desired should show a sharp rise of temperature, eyes slightly injected, loss of appetite, but no diarrhea. The work was complicated in a number of instances in the treatment of carabao, the animal not showing any rise of temperature, but developing a diarrhea and dying. This occurred several times, so that the inoculators drew the conclusion that an animal had a reaction when there was a marked injection of the eye with a dimunition in appetite, but with no rise of temperature.

The dosage of serum was found to vary but little in the different parts of the islands, the average being 30 c. c.

The motality percentages in the appended tables we believe to be somewhat misleading. In a number of instances the inoculators were unable to obtain the subsequent history of the animals after inoculation, and no doubt if they had been able to do so the death rate in certain localities would have been slightly increased.

In the provinces the opposition of the natives has been a great obstacle to the success of the work, not only from the trouble made in securing the animals, but also from the failure to bring them in for the taking of temperatures. This has made a great many of our records valueless, for it was impossible to tell whether or not the animals showed a proper reaction.

Another difficulty with which we have had to contend was inadequate transportation. The officials of the government have always given all the assistance which lay in their power, but as they themselves were encountering the same trouble it can be seen that but little assistance could be rendered.

The lack of trained inoculators confined the work to those districts in which rinderpest was epidemic. This explains why serum alone was given in so many cases. It is doubtful if the "simultaneous method" of inoculation is the best method to use in such infected localities, but the transportation was so irregular that it was deemed advisable if possible to bestow permanent immunity upon the animals instead of using the serum alone, the expectation being to return at some future date to complete the immunization. No doubt our mortality percentage has been increased over what it would have been had the work been done in clean localities, but we believe that what increase there may have been is more than counterbalanced by the amount of work which the inoculators were able to accomplish, as well as by doing away with the danger of allowing the temporary immunity to wear off and the animal so to contract the disease provided the inoculators could not return at the proper time.

In all the localities where the "simultaneous method" of inoculation has been used the epidemic has been brought to a rapid termination, only those animals which had been hidden by the natives subsequently contracting the disease.

Table No. 1 shows the amount of antirinderpest serum, in cubic centimeters, prepared and distributed during the period covered by the report.

TABLE NO. 1.—*Report of amount of rinderpest serum used in laboratory from January 1, 1903, to September 1, 1903.*

Month.	Prepared.	Returned.	Issued.	Balance.
	c. c.	*c. c.*	*c. c.*	*c. c.*
January	22,838		14,238	
February	18,794		1,000	
March	18,610		25,130	
April	25,528		33,322	
May	98,900		24,940	
June	100,400		133,725	
July	86,008	58,500	87,100	
August	188,550	50,100	118,608	
	559,628	108,600	438,063	230,165
Dropped				25,104
				205,061
Used at laboratory				27,611
On hand September 1, 1903				177,450

Table No. 2 shows the number of animals inoculated in the laboratory from January 1 to July 1, 1903, with the amount of serum and virulent blood used.

TABLE No. 2.—*Report of the amount of rinderpest serum used at laboratory from January 1, 1903, to September 1, 1903, and amount of virulent blood for same period.*

Month.	Amount serum.	Number inoculations with serum.	Amount blood.	Number inoculations with blood.
January	3,245	68	5,992	70
February	1,595	31	10,225	56
March	5,269	63	19,851	74
April	3,520	106	10,074	117
May	4,525	50	24,460	75
June	1,200	26	24,316	79
July	2,860	44	76,862	124
August	2,890	68	52,523	112
	25,104	456	224,204	707
Blood				707
Serum				456
Total inoculations				1,163

It is impossible to state how many animals were bled to death in obtaining this amount of virulent blood, some of the records having become mixed with those of animals dying from other causes. The animals used for this purpose were small, the average amount of virulent blood obtained from an individual being about 4,500 c. c.

Table No. 3 shows the results of immunizing cattle and carabaos at the laboratory. This also includes animals which were supposed to have rinderpest and which were brought to the laboratory for treatment.

TABLE No. 3.—*Method and result of immunizing cattle and carabao on admittance.*

Month.	Simultaneous method.		Serum method.		Treatment.	
	Number.	Deaths.	Number.	Deaths.	Number.	Deaths.
January	27	23				
February	4					
March	10	3	1		11	6
April	20		6			
May	11					
June	2					
July	2	1	11	2		
August	10	1	10	2		
Total	86	28	28	4	11	6

The death rate following the immunization of animals at the laboratory is greater than that obtained in the provinces. This can best be explained by the fact that nearly all the cattle brought to the laboratory for immunization were shipped from other ports, and as the majority of the ships are infected with rinderpest it was not difficult to predict what the results would be were the animals inoculated by the "simultaneous method," more especially when the animals are very probably in the incubative stages at the time of inoculation. The high mortality in January was due to the inoculation of a herd of carabaos imported from Borneo, which proved to be highly susceptible to the disease.

Table No. 4 shows the result of immunization of the vaccine calves and of the treatment given those which were sick at the time of arrival, as well as those inoculated with virulent blood for other purposes.

Table No. 4.—*Method and result of immunizing calves on admission.*

Month.	Simultaneous.		Serum.		Treatment.		Inoculated for virulent blood.	Deaths from other causes.
	Number.	Deaths.	Number.	Deaths.	Number.	Deaths.		
1903.								
January	19	1	7	....	4	4	1	....
February	10	2	23	....	12	12	3	....
March	5	2	29	1	12	12	1	....
April	2	....	25	....	21	21	....	....
May	2	....	13	....	5	5	2	1
June	....	....	22	4	3	3	4	3
July	....	....	28	15	....	....	....	....
August	....	....	23	7	....	....	....	....
Total	38	5	171	27	57	57	11	4
Per cent	....	13.15	....	15.8	....	100	....	....

All the calves coming under the heading of "Treatment" died. It may be stated, however, that a number of animals which were entered in the serum column which were but slightly attacked and received some treatment recovered. A large percentage of the animals were infected with both foot-and-mouth disease and rinderpest, and, as was stated above, this combination seems to be exceedingly fatal to both young and adult animals.

The treatment consisted in giving large doses of antirinderpest serum both subcutaneously and intravenously, with stimulation, but, as can be seen, the results were not encouraging.

Toward the latter part of the fiscal year the use of the "simultaneous method" with calves was almost discontinued, the majority receiving serum alone. This was done for reasons previously mentioned.

These animals subsequently subcutaneously received doses of virulent blood ranging from 5 to 20 c. c. in quantity sufficient to produce a reaction. The four dying during the month of June should not have been placed under this heading, as they showed elevated temperatures at the time of admission and developed foot-and-mouth disease the following day; they subsequently died of a combination of rinderpest and foot-and-mouth disease.

RINDERPEST INOCULATIONS IN THE PROVINCES.

On May 21, 1903, the Commission passed a law authorizing the board of health to employ 10 veterinary surgeons and 20 inoculators for the immunization against rinderpest of the cattle and carabaos of the Philippine Islands. The board of health have up to the present time been unable to obtain this number of employees capable of carrying on the work, there never having been more than two veterinary surgeons at work in the provinces at one time. The inoculators all took a course of instruction in this laboratory before being sent into the provinces. Their duties consisted principally in assisting at the inoculations, in taking temperatures, keeping the records of owners, etc. The majority of them were formerly hospital corps men of the United States Army and so did not require much training for the work.

Rinderpest having been reported at Surigao, on the island of Mindanao, Veterinary Surgeon John G. Slee and one assistant left for that port on February 1 with sufficient serum to inoculate 1,000 animals. Upon their arrival they found that rinderpest was not present at Surigao, but was said to be so farther south. An attempt was made to reach the afflicted district, but, owing to the season of the year and the nature of the coast, they were unable to go by water, and the impassable trails prevented them going overland, so they returned to Manila by the same boat, arriving February 10.

Upon receipt of a notice from the governor of Mindoro, stating that rinderpest was destroying a great many cattle and carabaos around Calapan, Veterinary Surg. John G. Slee, with one assistant, left Manila March 1, arriving at Calapan the following day. They found that rinderpest had killed a large number of cattle and carabaos in Calapan and its surrounding barrios, a number being sick at the time of their arrival. Difficult transportation confined the inoculations almost entirely to the immediate neighborhood of this town.

The first barrio visited was that of San Vicente, just across the river from Calapan. At this place, on March 3, 27 animals were inoculated by the "simultaneous method" and 6 with 50 c. c. of serum alone, because the latter seemed to have some of the symptoms of rinderpest. At the time of inoculation 10 animals were found to be suffering from the disease. On the following day Doctor Slee proceeded to Jolo, where 33 carabaos were treated by the "simultaneous method" and 5 with serum alone. A large number of animals had died in this place just previous to the arrival of the inoculators, and from the high mortality following the work it is probable that some animals were in the incubative stages at the time. The results of the inoculations will be noted in the appended table.

On March 29 Bulalo was visited, 39 carabaos inoculated by the "simultaneous method" and 1 with serum alone. Two of the former showed an elevation of temperature at the time of inoculation. Both subsequently died.

The next barrio was Baruyan. In this place 28 carabaos were treated, all by the "simultaneous method." Rinderpest was not present at the time of the visit, but a number of animals had died just previous to the arrival of the inoculators. The virulent blood employed at this place was a part of that used at Bulalo.

The barrio of Baco followed. At this place 38 animals were inoculated, 23 by the "simultaneous method" and 15 with serum alone. There was rinderpest present, a number of cattle showing either an injected eye or an elevated temperature. These were inoculated with 50 c. c. of serum each, no virulent blood being given. No transportation was available to the last-mentioned village, so the party was compelled to walk.

From Baco the inoculators proceeded to barrio Canubing. Considerable trouble was encountered here because of the unwillingness of the people to bring in the animals for inoculation, and after this was completed it was difficult to again see the animals for the purpose of taking temperatures, etc. Doctor Slee managed to inoculate 24 carabaos by the "simultaneous method" and 4 with 50 c. c. of serum alone. Rinderpest in this region is said to have first appeared in this barrio.

After completing the work at Baco, the party went to Bondoc, where 58 animals were inoculated by the "simultaneous method" and 3 with 50 c. c. each of serum. Rinderpest was also present in this place at the time of inoculation.

Suqui was next visited, rinderpest being present, and 33 carabaos were inoculated by the "simultaneous method."

After finishing at Suqui, a journey up the river brought them to Tanagan. At this place 60 animals were inoculated by the "simultaneous method." Rinderpest had not appeared in this locality at the time of the inoculation, and this probably accounts for the small percentage of deaths in this place.

Leaving Tanagan the veterinarians traveled on horseback to Siloney, where rinderpest was prevalant. At this place 21 animals were inoculated by the "simultaneous method" and 2 with 50 c. c. each of serum. Many difficulties were encountered on this trip, both from the prevalence of rinderpest and the opposition of the people.

Table No. 5 shows the results of the inoculations.

Eight of the animals inoculated by the "simultaneous method" showed some symptoms of rinderpest at the time of inoculation, and all of these subsequently died.

TABLE NO. 5.

	Simultaneous method.		Serum.		Total.
	Number inoculated.	Deaths.	Number inoculated.	Deaths.	
San Vicente	27	2	6	1	33
Jolo	[a] 38	8			38
Bulalo	[b] 41	[b] 6	1	1	42
Baruyan	28	4			28
Baco	23	7	15	1	38
Canubing	28		1	1	29
Bondoc	[c] 59	7	3	1	62
Suqui	33	2			33
Tanagan	60	1			60
Siloney	51		2		53
Total	388	37	28	5	416
Per cent		9.5			

[a] Five animals showed symptoms at time of inoculation.
[b] Two animals showed symptoms at time of inoculation.
[c] One animal showed symptoms at time of inoculation.

Excluding these seven animals, the percentage of deaths by the simultaneous method was 7.44.

During the month of October, 1902, Veterinary Surg. John G. Slee and Asst. Director Charles S. Sly inoculated on the island of Tablas 20 carabaos by the "simultaneous method" and 70 with serum alone. At this time the opposition of the natives to the inoculations was very great. In one instance half of the animals were driven into the mountains to prevent their being seen by the veterinarians.

The success of this expedition was very marked. Those animals which had been inoculated by the "simultaneous method" passed through numerous subsequent epidemics without one becoming sick, while those inoculated with serum alone remained well for about five months, at the end of which time a number contracted rinderpest, although the natives noticed that these animals appeared to suffer from a milder type of the disease than those which had not been inoculated. During the five months following the inoculations by serum alone the latter passed through several epidemics.

On March 28, 1903, a communication was received from the governor of Romblon requesting that inoculators once more be sent to Tablas to inoculate the remaining animals in that district, it having been observed that nearly all the animals which had been driven into the mountains had died of rinderpest while those that had been inoculated by the "simultaneous method" were well.

On April 15, 1903, Veterinary Surg. Thomas M. Owens, with Chief Inoculator Albert M. Newby and three assistants, left for Romblon, arriving at Santa Fe, Tablas, on April 21.

On the day following, in a small barrio 5 miles from Santa Fe, 25 carabao were inoculated, and on the 22d 55 more, all by the "simultaneous method." The animals were under observation for ten days, temperatures being taken daily, morning and evening. Sixty-five per cent showed reactions, as demonstrated by rise of temperature, etc. The mortality can be seen in the accompanying table.

On April 25, 35 carabao 1 mile from Looc, Tablas, were treated, 20 by the "simultaneous method" and 14 by serum alone. All animals which received serum only showed some symptoms of the disease at the time of inoculation. On April 26 they inoculated 21 animals 4 miles from Looc, 15 being carabaos. Two received serum only, and 1 of these died. Nineteen were inoculated by the "simultaneous method." Six cows, although showing some symptoms of the disease, were inoculated by the "simultaneous method;" of these 2 died.

Between April 30 and May 4, 184 carabaos were inoculated, 137 by the "simultaneous method" and 47 with serum alone. The records of all these animals could not be obtained, as they were the property of many different owners from every section around Looc.

On May 5 Owen and Newby inoculated 77 animals 3 miles from Looc; 37 of these were carabaos, and received the "simultaneous method." Forty cattle which were badly infected were given serum alone. These cattle were very wild, and no record of the results of the inoculations could be obtained.

On May 14 the workers inoculated 301 animals in Alcantra, Tablas, 243 by the "simultaneous method" and 58 with serum only. Ninety-eight of these animals were cattle. The animals were under close observation for twelve days.

On May 16 they inoculated 28 animals in Ferrol, Tablas, by the "simultaneous method." The temperatures of these animals were recorded daily and excellent reactions noted.

Between June 8 and 17 470 animals were treated in Odiongan, Tablas. These animals were free from rinderpest, but they were given serum only, as virulent blood could not be obtained. The serum given on this occasion was of a different shipment, and the results were not as satisfactory as the shipments prior and since that time. Deaths from rinderpest were reported as occurring thirty-five days after inoculation. However, the disease has made no headway and has since disappeared from that locality.

No more animals were inoculated during the month of June, but several hundred have been treated since then with excellent results.

The mortality percentage is probably higher than the appended table shows, but as previously stated it was almost impossible in certain localities to obtain subsequent records of the inoculated animals.

Between July 4 and 14 70 carabaos were inoculated at Odiongan, 40 by the "simultaneous method," resulting in 1 death; 30 received serum only, and 6 of these died. A new shipment of serum was used on this occasion.

Between July 17 to August 5 136 carabaos were treated at Despujol, Tablas, 89 by the "simultaneous method;" 47 received serum only. No records were taken of these animals after August 9, as only a small per cent had been inoculated after August 1.

TABLE NO. 6.—*Inoculations, island of Tablas, province of Romblon, by Doctor Owens and Mr. Newby.*

Date.	Simultaneous.		Serum.		Total.	
	Number.	Deaths.	Number.	Deaths.	Number.	Deaths.
Santa Fe, Apr. 22, 23	80	3	....	....	80	3
Looc, Apr. 24-May 8	214	....	111	8	325	8
Alcantra, May 17-21	243	....	58	....	301	....
Farrole, May 14	19	....	9	....	28	....
Odiongan, June 8-July 11	41	1	499	27	540	28
Despujol, July 17-Aug. 5	89	....	47	....	136	....
Total	686	4	724	35	1,410	39
Per cent	0.51					

On April 25 a request was received from a representative of the General Tobacco Company requesting the government to send inoculators to Florida Blanca and Pagyuruan, a barrio of the former pueblo, Pampanga Province, the report being that the animals were dying very rapidly from rinderpest. It was stated that rinderpest first appeared about one month before a veterinarian was dispatched in a lot of 20 calves shipped from Manila, the disease subsequently spreading over that locality and killing a great many animals.

Veterinary Surg. Harry Dell, director of animal industry, bureau of agriculture, with one inoculator made the trip, and, as can be seen by the appended table, obtained very successful results.[a] They left Manila April 29 for Florida Blanca, arriving the same evening.

The first inoculating done was at San Pedro, a barrio of Florida Blanca, where 15 animals were inoculated by the "simultaneous method," and 7 others, showing symptoms of rinderpest, were treated with doses of serum varying from 50 to 80 c. c. each. On the following day the party proceeded to Pagyuruan, where they treated 58 by the "simultaneous method" and 6, which showed symptoms of rinderpest, with 50 c. c. each of serum (no virulent blood). On May 2 they returned to San Pedro and inoculated 216 by the "simultaneous method" and 3 with 50 c. c. of serum only.

The mortality in this lot of animals was smaller than that observed in any other series of inoculations by the "simultaneous method," and the results were closely watched.

Table No. 7 shows the results of the inoculations in Pampanga Province.

TABLE NO. 7.—*Pampanga Province, Doctor Bell.*

Name.	Simultaneous method.		Serum.		Total inoculated.
	Number inoculated.	Deaths.	Number inoculated.	Deaths.	
San Pedro	15	0	7	5	22
Pagyuruan	58	0	6	1	64
San Pedro	216	1	3	2	219
Total	289	1	16	8	305
Per cent	0.34				

Telegrams were received from the presidente of the provincial board of health of the province of Pangasinan, stating that rinderpest was killing a great many animals in that province, and requesting inoculators. On June 24, Chief Inoculator Albert Newby, with three assistants, left for Dagupan, arriving the same evening, reporting by telegraph to the governor of the province.

Investigation failed to show any rinderpest in that section of the province, and telegrams sent to different local presidentes showed that no rinderpest could be found; so, having no virulent blood with which to work, the party returned to Manila.

Word having been received from Doctor Sherman, of the chemical laboratory (who was at that time making a trip through the southern islands in search of gutta-percha), that rinderpest was prevalent in Zamboanga, Veterinary Surg. Harry Dell, with two inoculators, left June 24 on the U. S. Army transport *Seward*, arriving at their destination on the evening of the 29th.

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[a] The thanks of the laboratory are due both to Doctor Bell and the chief of the bureau of agriculture, Prof. F. Lamson-Scribner, for their willing assistance in this work.

After conferring with the military authorities it was deemed advisable to demonstrate the efficacy and harmlessness of this method of immunization upon the carabaos at the government farm at San Ramon.

At that time there was but 1 animal suffering from rinderpest, although 50 had already succumbed to the disease. The beast appearing to be nearly dead, it was necessary to bleed at once, which was done by the light of a single candle.

Returning to San Ramon the following day, all the animals—8 in number—were inoculated. After completing the work the party returned to Zamboanga, leaving one inoculator to take temperatures and note reactions. Sometime was then spent searching for sick animals in order to obtain virulent blood for other inoculations, but none were to be found. There were no deaths resulting from the inoculations at the San Ramon farm.

Finding that, from the inability to obtain virulent blood, he would be unable to do any more inoculating, Doctor Dell returned to Manila, arriving July 20.

Numerous telegrams having been received from the governor of Tarlac, stating the rinderpest was killing a large number of animals in that province and requesting that assistance be furnished, Dr. H. Dell, with three assistants, left for Tarlac on the morning of August 3, arriving the same evening.

Only 1 sick animal could be found and this had nearly recovered from the disease. Finding it to be impossible to obtain virulent blood in the neighborhood and believing that similar trouble would very likely arise in the future, it was decided to ship virulent blood to Doctor Dell from the laboratory. This was done not only to supply the inoculators with virulent blood, which they could not obtain in Tarlac, but also to serve as a basis for future work.

The results were not all that could be desired, as but a small percentage of the animals inoculated with the blood showed a reaction.

There was no ice chest on the train, which did not arrive in Tarlac until late in the evening, thus preventing any inoculations until the following day. This subjected the blood to conditions which would very rapidly destroy its virulency and is probably the reason why a higher percentage of reactions were not obtained.

On August 5, in Tarlac and its barrio, San Isidro, 62 carabaos were inoculated by the "simultaneous method," with no deaths resulting therefrom. On August 10, 69 animals were inoculated at Tibag by the "simultaneous method," using a second shipment of virulent blood. This lot of blood was subjected to the same conditions in shipment as the first, and the results following the inoculations were the same in both cases.

TABLE No. 8.—*Inoculations, province of Tarlac, Doctor Dell.*

Number inoculated, simultaneous method:	
Tarlac and San Isidro, August 5–8	62
Tibag, August 10–13	69
Total	131

The government having made a contract for the purchase of carabaos in Shanghai, for restocking the islands, which have been nearly depleted by rinderpest, Asst. Director Charles S. Sly was ordered to Shanghai to superintend the immunization of the animals against rinderpest. The immunization was done by Messrs. Keylock and Pratt, the contractors, who prepared their own serum.

Finding that the mortality following the inoculations was very high, orders were received to ship some Manila serum to Shanghai. The results obtained with the Manila serum is but little better than that obtained with the serum prepared in Shanghai, which is easily explained when the conditions under which the inoculations were undertaken are known. The animals are purchased 139 miles up the river and brought down in junks to Shanghai for immunization, being subjected to excessive heat during this time.

During the trip from 2 to 3 per cent die from the effects of overcrowding and exposure, while upon arrival about 1 per cent show symptoms of rinderpest. It will readily be seen that animals in this condition will not be able to withstand the reaction following the "simultaneous inoculation," and that under such circumstances a high death rate is to be expected. In striving to find the dose of serum which would give the smallest death rate, it was found that just as good results could be obtained with 40 c. c. as with 100 c. c., which makes it appear that other conditions were the main factors in producing the high mortality percentage.

Table No. 9 shows the results of animals inoculated in Shanghai up to July 16 with the Shanghai and Manila serum:

TABLE No. 9.—*Inoculation government carabao, Shanghai, China, July 11 to July 18, 1903.*

KEYLOCK & PRATT SERUM.

Date.	Number inoculated.	Number deaths.	Total inoculated.	Total deaths.
June 11	73			
13	32			
14	11			
17	7			
21	6			
27	8			
Total	137	70	137	70

MANILA SERUM.

Date.	Number inoculated.	Number deaths.	Total inoculated.	Total deaths.
June 27	42	11		
28	18	5		
July 6	95	5		
7	54	1		
14	101	1		
16	27			
Total	337	23	337	23
Total inoculated			474	
Total deaths				93

A large number of animals have been inoculated since this date, but the reports are very incomplete, so will not be entered in the table. The mortality is about 40 per cent

Table No. 10 gives a summary of all provincial inoculations done from January 1 to September 1, 1903, and the results.

TABLE No. 10.—*Summary of rinderpest inoculations in the provinces, January 1 to August 31, 1903.*

Place.	Simultaneous.		Serum.		Total.	
	Number.	Deaths.	Number.	Deaths.	Number.	Deaths.
Island of Mindoro	388	37	28	5	416	42
Island of Tablas	686	4	724	35	1,410	39
Province of Pampanga	289	1	16	8	305	9
Island of Mindanao			8		8	
Province of Tarlac	131				131	
Total	1,494	42	776	48	2,270	90
Per cent	2.8		6.1			

VACCINE VIRUS.

The preparation of vaccine virus in the Tropics is one of great difficulty, not only from the intense heat, which, unless great care is taken, will produce a marked decrease in the strength of the virus, but also from the large number of diseases with which we have to contend. The calves required were obtained in Hongkong, the majority of the cattle formerly on the islands having died from rinderpest.

The animals are shipped to Manila in lots of 20 to 25, and in nearly every instance upon arrival a number show rinderpest in its first stages.

It was the intention at first to immunize the calves by the "simultaneous method," but as so many of them develop the disease within one or two days after arrival this was discontinued, and all are inoculated upon their arrival with 50 c. c. of anti-rinderpest serum and later with sufficient virulent blood (10 to 20 c. c.) to obtain a reaction.

It has been noticed that nearly all the calves, even though appearing to be in the best of health, show an elevation of temperature, sometimes as high as 41° C., upon arrival. Whether this is due to the exposure on the trip across the China Sea and to the change in water, food, and climate it is impossible to say, but it is sufficiently marked in nearly all that we are unable to use the animals for the preparation of the virus until they have been here for about ten days.

The method of immunization described above has been found to be the most successful. If the calf has been inoculated by the "simultaneous method" and a marked reaction obtained, it could not be vaccinated for about three weeks, but if it was given serum alone the high temperature noted above drops to normal in a few days, and in a week's time the animal could be safely vaccinated. By this method there was no necessity of waiting until it had recovered from the debility which very often follows inoculation by the "simultaneous method," and the mortality has been reduced to a minimum; nearly all the deaths occurring from rinderpest since this method has been in use have been in those animals showing the disease upon arrival or developing it one or two days afterwards.

A large number of the calves have foot-and-mouth disease upon arrival, and it is found necessary to put these in the quarantine stable for treatment. Very few animals die from this disease, and the ones which do apparently have been infected for some time.

No cases of tuberculosis have been observed in the calves purchased, and the city veterinarians inform me that they have never seen a case in the islands. This may partially be accounted for by the fact that the cattle are very seldom housed, being allowed to roam at will.

During the hot season it was found necessary to concentrate the virus which was to be used for vaccinating the calves and to decrease the area scarified to nearly one-half that feasible in the cooler months; but even with these alterations in technique the results while high temperature prevailed were not as good as could be desired.

Arrangements are being made whereby the vaccine stalls attached to the new laboratory can be kept cool in all seasons of the year. It is believed that this will not only prevent the shrinkage in yield, but will also tend to greatly increase the strength of the virus.

A series of experiments were undertaken to see if a new stock of vaccine virus could not be obtained from a case of smallpox. The experiments are not completed, but the results so far would lead me to think that new stock can be prepared by successive passages through monkeys.

A calf and monkey were vaccinated with lymph taken from three vescicles of a well-marked case of smallpox in the vesicular stage.

The calf never showed any local reaction that was observable.

The monkey showed nothing until the fourth day, at which time a slight induration was noticed in the vaccinated area. On the fifth day this was more apparent, but there were no signs of papules or vesicles. On the sixth day the induration was very marked, but still no papules or vesicles. A portion of the indurated area was removed on the eighth day and macerated with a 60 per cent solution of glycerin in water (virus "A 1"). There was no general eruption observable.

With virus "A 1," a calf and monkey were vaccinated. As in the preceding experiment the calf failed to show any local reaction.

Four days after the monkey was vaccinated there was noticeable a slight induration, becoming more marked during the following forty-eight hours, at which time there was noticed a few papules scattered over the vaccinated area and in the skin for several centimeters surrounding During the following twenty-four hours these assumed a vesicular appearance, but were very small. The scarified area was markedly indurated. These vesicles were allowed to remain two days, and were then collected (virus "A 2") and the virus prepared as before. At the time of collection the vesicles were well filled and about the size of a grain of wheat. The induration was not so marked as in the first monkey. A few scattered vesicles were to be found 5 or 6 cm. from the margin of the vaccinated area. After collection there was seen to be a hard indurated mass, which, from the pressure used in collecting the virus, appeared to have become separated from the surrounding tissues. This mass was not removed at the time and there was no subsequent sloughing.

Virus "A 2" was used to vaccinate a monkey and calf. As in the preceding experiment the calf failed to show any local reaction.

The monkey after four days showed some induration over the vaccinated area. It was noticed in this case that the induration appeared earlier than in the preceding monkeys and was not so marked at any stage. On the sixth day distinct papules were noticed scattered over the vaccinated area. These papules were larger and somewhat more numerous than those noticed on the preceding monkey. Two days later these had developed into vescicles which were larger than those previously seen with this strain of virus. The virus ("A 3") was collected on the eighth day and prepared as usual.

Virus "A 3" was used to vaccinate a calf and monkey. In this calf there appeared to be a thickening of the skin on the fifth day, but nothing very distinct, and if such changes were present they disappeared very rapidly.

The monkey showed numerous papules scattered over the vaccinated area on the fourth day. The induration was slight as compared with the previous one. By the sixth day the vesicles were fairly thick, although small. The virus "A 4" was collected on the eighth day, at which time the vesicles were much larger than those previously seen.

Virus "A 4" was used to vaccinate a calf and a monkey.

This calf was vaccinated by two methods, viz, first, a scarification was made along one side of the linea-alba and the virus rubbed in; second, with a hypodermic needle filled with the virus; very superficial punctures were made and a small amount of the virus forced into the deeper layers of the skin.

Some induration was noticeable on the third day, and on the following day a few papules were to be seen scattered over the sites of the inoculations. By the fifth day these had developed into well-marked vesicles. The vesicles were unevenly distributed over the vaccinated area, and there was considerable swelling in the spots where the virus had been injected with the hypodermic needle; these afterwards terminated in abscesses.

The virus "A 6" was collected from the scarification on the sixth day. At the time of collection the vesicles were well filled and about the size of a bean. On the following day the virus over the "insertion area" was collected. These vesicles were considerably larger than those seen on the scarified area, although on the day previous they appeared smaller.

The monkey vaccinated with virus "A 4" presented about the same appearance as the one from which virus "A 4" was obtained, with the exception that the vesicles were more numerous. The virus "A 5" was collected on the eighth day and prepared as usual.

Virus "A6" was used to vaccinate a calf and monkey, and in both animals the results were indistinguishable from those obtained with the regular vaccine virus.

As can be seen from this series of experiments, no results were obtained by vaccinating calves with smallpox until it had been passed through four monkeys. The calf vaccinated with virus which had been passed through four monkeys gave only fair results, but the virus then obtained gave excellent results when subsequently used upon other calves, in fact gives larger vesicles.

This virus was tried on employees of the laboratory, but as all showed scars following previous successful vaccinations no results were to be expected. It has not yet been tried for first vaccinations. In vaccinating a calf the following method is used: The part beginning about the level of the tenth rib and to the perineum, and extending about 30 cm. either side of the median line, is first thoroughly scrubbed with soap and water and shaved. After shaving it is again scrubbed with soap and water, rubbing with the hands only. The surface is then sterilized with a 3 per cent solution of carbolic acid, alcohol, and water used in the order named, care being taken that all the acid and alcohol are removed with sterile distilled water. The parts are covered with sterile gauze until the operation begins.

Beginning about 15 to 20 cm. above the umbilicus and 6 to 10 cm. to the outer side of the median line, longitudinal scarifications are made extending into the perineum. The virus is then rubbed in with a sterile brush, after which the surface is further scarified by making lines perpendicular to the first.

If the calf is large two series may be made on the same side. After scarification the parts are covered by sterile gauze, the gauze being kept in place by an abdominal bandage having bands which fasten over the back. If a male calf the gauze should be changed twice a day, or as often as soiled.

The virus is collected when the vesicle is "ripe," generally about the fourth or fifth day.

In collecting the virus the abdomen is first washed with warm, sterile distilled water until the parts are thoroughly softened. It is then washed with a soap solution, gently rubbing with a soft brush to remove the desquamated epithelium. After this a 3 per cent solution of carbolic acid is allowed to flow over the parts, this being removed with sterile distilled water. The virus is then collected and put in a previously weighed sterile Petri dish and again reweighed.

The virus is then passed and repassed through a vaccine mixer and, as it becomes more finely macerated, four times its weight of a solution containing 60 per cent of glycerin is added very gradually until the whole is thoroughly mixed. To test it a platinum loop full of the mixture is added to a test-tube containing about 20 c. c. of distilled water and thoroughly shaken; if any large particles are to be seen after thoroughly shaking, it should be repassed through the machine and again retested.

The virus is then drawn up into sterile capillary tubes and the ends sealed in a flame or placed in sterile vials holding 100 doses each.

Table No. 11 shows the number of calves bought, calves vaccinated, number from which virus was collected, and the number of doses prepared during the period covered by this report.

TABLE No. 11.—*Calves bought and vaccinated and vaccine prepared and issued.*

Month.	Bought.	Vaccinated.	Collected from—	Prepared.	Issued board of health.	Issued laboratory.
January	12	19	17	144,888	145,825	3,800
February	49	27	22	202,410	158,805	5,400
March	52	39	24	93,700	122,645	7,800
April	57	30	33	339,700	240,600	6,000
May	0	9	5	20,300	100,000	1,800
June	25	27	23	32,000	49,000	5,400
July	27	36	31	100,900	79,800	7,200
August	[a] 24	12	9	49,400	43,280	2,400
Total	246	199	164	983,298	939,955	39,800

[a] In the month of August, 18 vaccine calves were traded for new ones.

To board of health	939,955
To serum laboratory	39,800
	979,755
Prepared	983,298
Balance	3,543

It will be noticed that there is quite a discrepancy between the number of calves vaccinated and the number from which the virus was collected. This was caused by the appearance of foot-and-mouth disease among the calves after they had been vaccinated; also in a few instances by the development of rinderpest.

PLAGUE PROPHYLACTIC.

The preparation of a plague prophylactic was begun during the year 1902. It was the intention at that time to prepare Haffkeine's prophylactic, but the board of health, learning that the Indian government was having considerable trouble as a result of some very severe local reactions, decided that it would be preferable to use some other prophylactic which would not cause this trouble. For this reason "Shiga's method" of preparing plague prophylactic was used instead.

A fresh culture obtained by passage through a guinea-pig or monkey was used. The culture media consisted of ordinary agar in test tubes 25 mm. in diameter. In making cultures, a heavy platinum wire, the end of which is wound into a flat coil about 15 to 18 mm. in diameter, is used. The cultures were allowed to remain in the incubator for forty-eight hours, at a temperature of about 32° C.

The bacilli were scraped off the agar at the end of this time by means of a large flattened platinum wire, the end of which had been bent at right angles. The bacilli were transferred to a glass mortar which had previously been sterilized for two to three hours at a temperature of about 180° C. Before sterilizing, the mortar was accurately weighed and again reweighed after the addition of the bacilli. To overcome any error in calculation due to agar being present with the bacilli when it was reweighed, the following steps were taken: Two sterile flasks, one empty and the other filled with a 0.9 per cent solution of sodium chloride, are accurately weighed. Then with a sterile pestle the saline solution is gradually and thoroughly mixed with the bacilli until the glutinous appearance has disappeared and an even emulsion has been formed. This is then passed through a very fine meshed wire strainer (to remove all the agar) and into the sterile empty flasks, care being taken to remove all the bacilli by means of fresh saline solution. Both flasks are then reweighed. The difference in weight of the flask originally containing the solution shows the amount added to the bacilli and now in the other flask. The difference in weight of the other flask, above that of the solution added, shows the actual weight of the bacilli present.

After finding the amount of the bacilli present the flask is placed in a water bath, and the water brought to a temperature of 60° C. and held at that temperature for thirty minutes.

After sterilization, the weight of the bacilli being known, the amount of sodium chloride solution required to be added so that 1 c. c. shall contain 0.006 gram is then found, 10 per cent is deducted, and this is replaced by a 5 per cent solution of carbolic acid.

After preparation and before distribution, cultures are made and one or more animals are inoculated to make sure that the prophylactic is sterile.

Table No. 12 shows the amount of the prophylactic prepared and the amount delivered to the board of health from January 1 to September 1, 1903.

TABLE NO. 12.—*Plague prophylactic.*

Month.	Number cubic centimeters prepared.	Amount distributed.	Balance.
February	1,514	350	....
March	7,160	390	....
April	....	1,440	....
May	8,604	15,100	....
June	7,128	6,520	....
July	16,920	7,556	....
Total	41,326	31,956	9,370

This prophylactic has been used almost entirely for the inoculation of the Chinese in the city of Manila. Heretofore the Chinese population has furnished about 60 per cent of the total number of plague cases, but since the inoculating has been in force the percentage has rapidly decreased.

According to the board of health reports, no case has occurred in those who have been inoculated twice, and but very few in those who have been inoculated once. In several instances where a house was occupied by a number of persons and all were inoculated but one, the noninoculated person contracted the disease, while those remaining, though probably subjected to the same exposure as this case and being in contact with it until found by the board of health, were not affected.

No cases have been reported in which there have been any bad results following the inoculations, either local or general in character.

ANTIPLAGUE SERUM.

Very little has been done toward the production of this serum. While we have four horses on hand at present for its production, the large amount of work caused by the increased demand for vaccine virus, the preparation of antirinderpest serum and plague prophylactic has taken the entire time of the small force at the laboratory.

Three methods are now being used for the preparation of this serum: First, inoculating the horse with the sterile bacilli in gradually increasing doses, until 7 grams are given at one time, the horse then being bled in the usual manner; second, inoculating with a sterile thirty days' old bouillon culture in gradually increasing doses; third, with the nucleo-proteid after Lustig's method.

Only one horse has been bled and this one had been immunized with the sterile bacilli. This animal was bled May 25, and the serum tested as usual. The serum has not yet been used in sufficient quantity to make any statement as to its efficiency.

EXHIBIT B.

REPORT OF THE CHEMICAL LABORATORY, PREPARED BY DR. P. L. SHERMAN, CHEMIST.

The details of the routine work done by the chemical laboratory during the past year are given in the accompanying tables, which show the diversity of analyses undertaken as well as the number of departments of the Government which have taken advantage of the opportunity offered by it. There is no private assay office nor general analytical laboratory in the Philippines, and consequently the Commission authorized the bureau, by resolution dated December 1, 1902, to undertake custom analyses at a price covering the cost of material and work expended. As might be expected, the majority of the analyses thus undertaken were of ores and natural products, the values of which it was desired to know. Next in importance came physiological work for the practicing physicians of the city. Facilities for the latter are most necessary, as few physicians here are in a position to do this work themselves. The use of benzoyl-acetyl hyperoxide continued in Manila, more especially on demand from the board of health, which used large quantities in San Lazaro Hospital. The results of the work in that institution will be given in the special report of the board of health. Table No. 1 shows the amount of acetozone distributed, Table No. 2, the routine work of the laboratory.

TABLE No. 1.—*Acetozone.*

Month.	Board of health.			Private parties.	
	Crystals, grams.	Capsules.	Solution L. (1-1000).	Capsules.	Solution L (1-1000).
August		800	600		
September	695	717			
October	500	405			
November	505	315			
December	750				
January	735	210			
February	600	235			
March	900		120	30	
April	1,100				
May	750			89	140
June	890				
July	750			89	101
August	1,100			276	
Total	9,275	2,682	720	484	241

TABLE No. 2.

	Attorney-general.	Board of health.	Bureau of agriculture.	Bureau government laboratories.	Bureau non-Christian tribes (ethnological survey).	Civil hospital.	Consulting engineer.	Custom-house.	Exposition board.	Forestry bureau.	Insular purchasing agent.	Insular treasurer.	Mining bureau.
Alcohols													
Assays				3					73				
Beverages		10											
Celluloid											1		
Coals				3									
Coins								8				2	
Criminal (not poison)													
Disinfectants		3		1				2					
Feeds			1										
Flavoring extracts								1					
Food products		9			3			4					
Fertilizers			3										
Gravels							2						
Gums, resins, etc			2	2						2			
Human milk													
Lubricants											1		
Metals and alloys								21					
Medicines		9		12		1		1					
Minerals					1		3		5				4
Oils		1		3							2		
Paints								22					
Pathological						6							
Petroleum											2		
Perfumes													
Poisons	2	6				4							
Protective coating													
Seeds			2	2									
Soap		2											
Soils			8										
Textiles								7					
Urines		9		1		276							
Waters:													
Mineral		8											1
Potable		1				1	13						
Total	2	58	16	27	4	288	18	66	78	2	6	2	5

TABLE No. 2—*Acetozone*—Continued.

	Miscellaneous.	Private.	Prosecuting attorney.	Secretary of the interior.	United States Army.	Secret service.	Philippine constabulary.	Cold storage.	Bureau of architecture.	Bilibid prison.	Municipal board.	Total.
Alcohols	1	7										8
Assays		71		3								150
Beverages												10
Celluloid												1
Coals		5		1	2							11
Coins												10
Criminal (not poison)			1			1						2
Disinfectants												6
Feeds							1					2
Flavoring extracts												1
Food products		2										18
Fertilizers												3
Gravels												2
Gums, resins, etc												6
Human milk		2										2
Lubricants								1				2
Metals and alloys		1										22
Medicines					2							25
Minerals				1								14
Oils		1										7
Paints									1			23
Pathological										1		7
Petroleum		2										4
Perfumes		3										3
Poisons		1	2									15
Protective coating									2			2
Seeds												4
Soap												2
Soils												8
Textiles												7
Urines		68										354
Waters:												
Mineral				4	3							16
Potable					1						1	17
Total	1	163	3	9	8	1	1	1	3	1	1	764

Although the above shows the amount of routine undertaken, it does not touch upon other important work now in progress, and begun with the object of systematically examining, analyzing, and describing the raw products and undeveloped resources of the islands. Owing to the heavy demands upon the time of the chemists made by analytical work, but one subject—the Gutta-Percha and Rubber of the Philippine Islands—has been completed sufficiently to justify publication. The others, however, are well under way, and the amount accomplished is given below. The completed researches will be published during the coming year.

The principal subjects now under investigation are:

THE MINERAL RESOURCES.

Considerable material available for preparing a systematic report on the value of Philippine ores, based upon actual assays and analyses, has been collected during the past year and in large part worked up. While some of this material on the mineral resources has been furnished by private parties, most of it was collected by the agents of the St. Louis Exposition Board for exhibition purposes. The collection was made so as to be as comprehensive as possible and to illustrate the distribution of economic minerals in the islands, yet it must be borne in mind that the Philippines contain no mines at the present time which are really in working condition, and the samples, or more often specimens, were generally collected from surface indications and outcroppings, from small native workings, old abandoned shafts, and in fact from the best places available where systematic prospecting is still lacking and even explosives unobtainable.

Bearing in mind that the great backbone of the Philippines, from Luzon in the north through all of the principal islands to Mindanao in the south, presents a great variety of minerals throughout almost its entire length, the work now in progress at the laboratory is being planned with a view of systematically collecting, analyzing, and classifying the minerals of the various provinces and islands from one end of the Archipelago to the other. This work will be greatly aided in the future by topographic and geologic surveys. At present the specimens collected from the various regions considered most promising are most useful in indicating the diversity of the work outlined, and also to some extent to show the fortune attending the prospectors and miners.

The mineralogical products so far collected are, in brief, as follows:

COAL.

The coal reported is all of the black and brown lignite variety, the best black specimens having a heating capacity of two-thirds to three-fourths of that of Cardiff coal. None are coaking, except one from central Luzon, but as nearly all specimens obtained were badly weathered, due allowance must be made. The sulphur content is small and moisture high. Samples were taken from Abra, Bataan, Bulacan, Morong, Rizal, Cagayan, and Payabas, in Luzon, and the islands of Marinduque, Mindoro, Mindanao, Cebu, Masbate, Panay, Bataan, Samar, and Negros. The black lignites from Cebu, Bataan, and Negros are apparently the best. The government is now investigating the Bataan Island coal deposits, and good samples taken at a depth will aid much in determining the real value of Philippine coal, and in all such expeditions it is of the greatest importance that the laboratory be furnished with good samples of all materials collected, together with data as to their location and the conditions under which they are obtained. The following table, No. 3, gives the analyses made at this bureau during the past year and shows the comparative merits of the respective classes:

TABLE No. 3.—*Coal analyses, bureau of government laboratories, 1902–3.*

Locality.	Water.	Volatile compound matter.	Fixed Carbon.	Ash.	Iron.	Sulphur.	Phosphorus.
Philippine lignites	18.50	37.73	38.10	5.66	0.48	0.87	....
	5.00	42.21	49.70	3.08	.52	.22	0.05
Alpaco, Cebu	13.35	42.20	43.73	.71	....	....	....
Danao, Cebu	8.96	35.11	52.92	3.00	....	....	....
Compostela, Cebu	8.83	35.10	52.78	3.28	....	....	....
Mount Uling, Cebu	9.30	39.24	48.64	2.81	....	....	....
Do	17.30	44.51	34.67	3.52	....	....	....
Zamboanga, Mindanao	4.64	38.38	55.19	1.78	....	....	....
Surigao, Mindanao	17.37	41.80	33.44	7.38	....	....	....
Montalban	1.75	38.19	47.87	12.18	....	....	....
Western Negros	21.20	40.80	31.50	6.50	....	....	....
Calatrava, Negros	19.33	32.37	39.91	8.39	....	....	....
Kabanklan, Negros	15.03	33.50	44.67	6.79	....	....	....
Japanese coal	2.38	38.27	52.58	6.77	.33	.21	.32
Do	2.10	38.10	45.90	13.90	....	....	....
Do	1.71	25.53	67.06	5.70	.42	1.07	.14
Australian coal	2.00	32.60	56.60	8.80	....	....	....
Do	2.47	32.15	59.20	7.17	.24	.22	.66

GOLD.

The gold ores are quartz, generally decomposed and iron stained when taken from the surface, and pyritic when taken at even small depths under ground. Benguet as a rule has less sulphur in its ores than Lepanto. The former appears free milling, while the latter are refractory. The gold values from the assays made, range from nothing up to $120 a ton. About one-half showed no value, while the other half averaged less than $5 a ton.

Gold-bearing quartz has been collected from Cagayan, Bontoc, Lepanto, Benguet, Rizal, Batangas, Laguna, Bataan, Pangasinan and the Camarines in Luzon, and Panay, Masbate, Mindoro and Mindanao. It is also reported from many other islands.

COPPER.

The majority of the samples received were of sulphides, while the rest was composed of metallic copper (Lepanto and Masbate), malachite (Benguet), and chalcopyrite (Mindoro, Cagayan). A sample of copper glance from Lepanto assayed 80 per cent copper, and many others were also of high value. One large deposit in Benguet assayed 18 per cent copper.

SILVER.

Although found in all gold and many copper ores, it has so far not been found in paying quantities.

IRON.

Samples were received from many localities and in many islands, those from the large deposit at Angat, Bulacan province, proving the best. It is a pure hematite, and adapted to steel reduction.

LEAD.

Very fair specimens of the sulphide from Bontoc (Luzon) and Cebu have been received.

SULPHUR.

Specimens are at hand from Bontoc, Cagayan, Negros, Albay, Batangas, and the island of Biliran.

LIMESTONE.

The best marble probably comes from the island of Romblon, though present also in many other localities. Limestone for building and for the manufacture of lime is widely extended over Luzon and the islands of Panay and Mindanao. Coral limestone abounds on the islands of the southern Philippines and Mindoro.

SALT.

No deposits of rock salt have so far been reported, but salt springs are found in Bontoc, Ilocos Norte and Sur, Nueva Viscaya, Union in Luzon, and on the islands of Marinduque, Paragua, Bohol, Negros, Panay, and Samar.

CLAYS.

Some good kaolin and several varieties of clay samples have been collected from many localities. They include both red and white varieties.

MISCELLANEOUS.

Metals of platinum group.—Some eight samples have been examined, but so far no trace has been found of these metals. Platinum is reported, on good authority, from the Rio Grande Valley, Mindanao.

Basalt is reported from Rizal (Luzon); Tufa in large quantities is found in the vicinity of Manila, Laguna, and Batangas. It is the principal building stone used in Manila. Sandstone, from Panay and Balabac; charcoal, from Catubig (Samar); stalactites, from Capiz (Panay); stalagmites, from Bontoc; gneiss, from Camarines Norte; diorite, from Camarines and Rizal; porphyry, from Lepanto.

MINERAL WATERS.

The following table, No. 4, gives the composition of the waters from various parts of the islands analyzed at the laboratory during the past year. As will be seen, only two of the samples called mineral waters really showed total solids in sufficient quantity to warrant the name. A more extended investigation is necessary to discover if any valuable medicinal waters are found in the islands.

TABLE No. 4.—*Analyses of mineral waters, bureau of government laboratories, 1902–3.*

Locality.	Total residue.	Fixed residue.	Free ammonia (NH_3).	Iron oxide (Fe_2O_3).	Alumina (Al_2O_3).	Calcium (CaO).	Magnesium (MgO).
Saline waters:							
San Miguel, Camarines	414.00	308.00	....	1.98	0.46	64.60	35.80
	450.00	366.00	Trace.	3.83	7.06	61.20	35.40
Bued River, Benguet	320.00	....	....	....	....	71.90	4.90
Benguet	1,447.00	....	....	....	....	197.00	4.30
	347.00	....	....	....	....	109.00	20.90
	563.00	....	....	....	....	141.40	17.30
Twin Peaks, Benguet	294.00	....	....	....	....	71.10	7.10
	271.00	....	....	....	....	87.00	5.50
Sulphureted waters:							
Bued River, Benguet	1,556.00	....	....	....	....	180.00	3.20
Twin Peaks, Benguet	355.00	....	....	....	....	101.00	3.60
	340.00	....	....	....	....	85.70	11.90
Table water, Bued River, Benguet	49.30	30.00	Trace.	....	....	Trace.	(a)

Locality.	Sodium (Na_2O).	Chlorine (Cl).	Silica (SiO_2).	Sulphuric acid (H_2SO_4).	Carbonic acid (CO_2).	Hydrogen sulphide (H_2S)
Saline waters:						
San Miguel, Camarines	63.20	17.70	128.20	....	(a)	....
	40.50	17.70	128.40	....	(a)	....
Bued River, Benguet	....	....	....	....	....	2.07
Benguet	....	1,038.00	....	....	....	.65
	....	....	....	....	....	.96
	....	Trace.	....	....	....	....
Twin Peaks, Benguet	....	Trace.	....	....	....	....
	....	....	....	....	....	4.67
Sulphureted waters:						
Bued River, Benguet	....	460.00	....	....	....	[b] 12.10
Twin Peaks, Benguet	....	Trace.	....	....	....	[b] 17.40
	....	....	....	....	....	[b] 7.32
Table water, Bued River, Benguet	....	Trace.	(a)	7.97	Trace.	....

[a] Small amount.

[b] Cubic centimeters per liter.

NOTE.—All figures are in parts per million.

RESINS, GUMS, AND WOOD OILS.

In a large number of places throughout the islands from Luzon to Mindanao and Paragua quantities of resins (breas) have been taken for many years, and the supply is far from being exhausted. Most of this is the gum copal of commerce, though some is reported under the name of dammar gum. The laboratory is now analyzing this and other resins, some of which contain a large percentage of essential oils. To this latter class belong the "breas" or Pili gum, which is collected from forest trees of the genus *Canarium*. A gum similar to the gum chicle of Yucatan has been found in several islands and is now being worked up with the view of ascertaining its commercial value. It probably comes from a species of *Ficus*.

Panao (wood) oil is being exported to some extent for use as varnish oil. The experiments now under way show it to be composed of an essential oil and a large amount of a soft resin. A sample of manapo oil has been received from Baler, province of Principe, which is peculiar in that it contains an apparently unknown essential oil in combination with a white crystalline resin.

Through the exposition board samples of several hitherto unreported resins and two gums have been collected, and their analysis is now under way. The gums are water soluble and resemble gum senegal somewhat, while the resins are of various colors and all apparently contain arromatic oils. The "breas" have received the greatest attention, and so far, two distinct varieties of white "brea" have come to the laboratory. They differ markedly in that one from *Canarium luzoniense* contains 21.18 per cent of pure pinene, while the other, the usual brea of commerce, contains 9.3 per cent of phellandrene. The results of the present investigations on the gums and resins will be published as a bulletin as soon as they are completed sufficiently to warrant publication.

COPRA AND COCOANUTS.

The copra and cocoanut industry is practically second to none in the islands, and the laboratory is now engaged in analyzing large numbers of nuts of all ages and the dried copra from many localities. The various samples are being worked over into copra and the percentage of oil, water, and cake determined. So far the work has shown great variation in nuts from different localities and even from the same tree. The quantitive analyses will be graphically displayed at the St. Louis Exposition. It is hoped that the analyses will shed some light on the question of the benefit or harm of sea air and water on the yield and value of cocoanut trees, as well as the variations in oil-producing capacities between different regions.

TAN BARKS AND DYEWOODS.

In connection with the forestry bureau the laboratory is now investigating some 200 specimens of this class of forest products collected in Luzon and Mindoro. Although some apparently good colors have already been extracted, it is too soon to give an opinion as to their real value. Some of the tan barks are rich in tanning principle.

SOILS.

In connection with the bureau of agriculture, the systematic analysis of soils from the various agricultural centers for tobacco, coffee, rice, hemp, cacao, cocoanuts, etc., has been undertaken. So far samples of soils have been received from several of the government experimental farms and analyses made. The work of soil analysis while in itself giving the composition of individual soils, has not the comprehensive scope which would be given by a geologic survey.

GUTTA-PERCHA AND RUBBER.

The material for this report was collected under the direction of both the bureaus of forestry and government laboratories. As early as 1900 the attention of the government was called to the fact that many of the wild tribes in the southern islands were engaged in cutting down large numbers of forest trees in order to secure the gutta-percha and rubber which they contained. These products they bartered to the Chinese, who in turn exported them to Singapore.

The matter was considered important enough to demand investigation, because—

1. The trees were being cut down in violation of forestry rules.
2. No forestry dues were paid by those either collecting or exporting these forest products.
3. Judging from the experience of the English and Dutch in the Malay Peninsula, Sumatra, and Borneo, it would only be a question of a short time, if the wild tribes were allowed to have their own way, when there would not be one tree of this class left standing in the Philippines.

Unfortunately there was no information at hand on the subject. In June, 1901, I was sent as a special agent of the forestry bureau to Singapore, the Malay Federated States, and Java to study the laws and conditions there under which these forest products were grown, collected, and marketed.

Provided with the information thus gathered, and which is detailed below, upon my return to Manila, four months later, I was again sent to the southern Philippines to repeat my investigations, and as before to make collections of herbarium material and samples of the various kinds and grades of gutta-percha and rubber found there.

This first southern trip consumed several months, for while specimens of marketable gutta-percha and rubber could be secured in the principal towns, all herbarium material and gums from each tree species had to be taken personally to avoid all sources of error.

The trips along the coasts and rivers of many of the islands were made in small native sail and row boats, and the journeys into the forests of the interior were done on foot with native guides and carriers. The native gum collectors themselves, their method of felling the trees and vines, securing the gutta-percha and rubber, preparing the same for market, the prices they received both in money and barter, were thus seen at first hand, and of course opportunity secured for making herbarium collections of the various species of trees and vines yielding gutta-percha and rubber. In the principal towns the market conditions of supply, demand, prices, etc., were studied.

Upon my return to Manila I was ordered transferred to the bureau of government laboratories, in order that all specimens collected might be tested chemically and physically so as to determine their relative values. This analytical work, as well as several subsequent trips to the southern islands, Paragua, Mindoro, and Culion, in search of new material, has been carried out and is here reported.

The identification of the various species of gutta-percha and rubber trees and vines was kindly undertaken by Mr. E. D. Merrill, botanist for the bureau, who also assisted greatly in collecting herbarium material in Mindoro and Culion.

PART I.—GUTTA-PERCHA.

HISTORICAL.

Like many other commercial products coming from oriental lands, the date of the discovery of gutta-percha is lost in oriental history. The famous Tradescant Brothers, in 1656, exhibited in their museum of curiosities, in London, a piece of gutta-percha which they had secured in the Far East. Also in 1842, Dr. William Montgomery, an English surgeon, saw whips and other articles of gutta-percha in use by the natives of Singapore. It is therefore safe to assume that the real discovery of this remarkable substance was made at some time previous to either of these dates.

The western, or commercial, discovery of gutta-percha was delayed until 1843, when both Doctors Montgomery and D'Almeide sent specimens of the gums and leaves of the tree to London. While the specimens of D'Almeide were neglected, those of Montgomery received enough attention from the scientists of the Royal Society of Arts to demonstrate some of the uses to which the substance might be put. The botanists agreed that the tree belonged to the family Sapotaceæ, but as neither flowers or fruit were at hand they could go no further with the identification.

In 1847 the greatest advance was made toward the utilization of gutta-percha. Considerable amounts had from time to time been shipped to London, and experiments were made to determine its physical and chemical characteristics. Luckily a sample fell into the hands of a young German artillery lieutenant, Werner von Siemens, who was then experimenting with insulating material for subterranean and submarine telegraphic cables. The ease with which gutta-percha lent itself to this object, and the high efficiency obtained, induced him to construct a machine for insulating cables. The method he adopted, as well as the kind of machinery, has, with few modifications, been in use ever since then.

The subsequent history of gutta-percha runs parallel with that of submarine and subterranean electric cables, for three-fourths of all the gutta-percha produced has been used on them. With the construction of the great trans-Atlantic cables in the sixties and seventies of the past century, the demand for gutta-percha became enormous, and the details of its value and ready market traveled all over this part of the Orient.

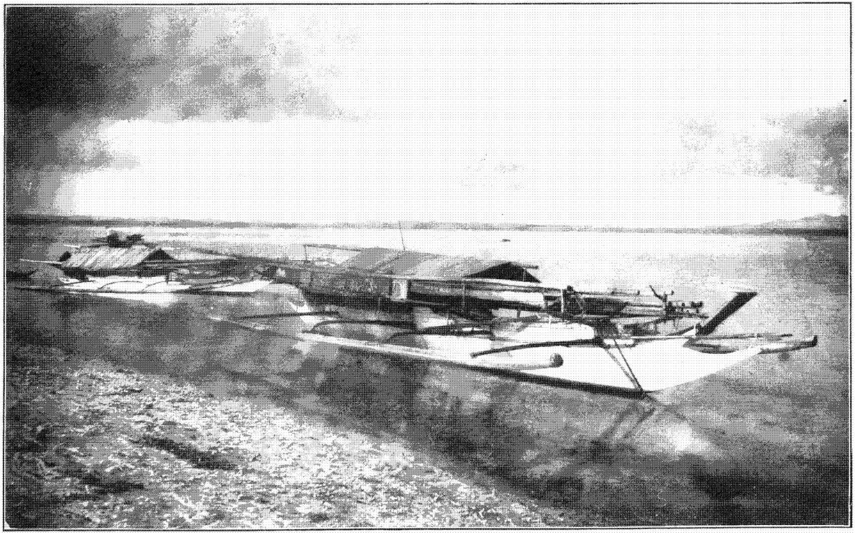
When the Malay Peninsula, adjacent to Singapore, failed to supply sufficient quantities to meet the demand, the nearby islands of the Rhio Archipelago and Sumatra were invaded, and rich finds made. Finally Borneo was included in the producing zone and lastly the Philippines.

At what date the Philippines began to export gutta-percha to Singapore, the center of the gutta-percha trade, can not be learned with any degree of certainty. Probably twenty years ago varying quantities were exported, but apparently the trade died out, owing, it is said, to the wholesale adulterations practiced by the Chinese exporters and the prohibitory laws of the Spanish Government. For the last ten years prior to the American occupation of the islands but little had been exported, though the collecting and exporting began very soon afterwards and increased at once to large proportions.

BOTANICAL.

In the year in which Von Siemens made his great discovery of the insulating value of gutta-percha for submarine cables, Sir Joseph Hooker, Bentham, and others worked out the status of the gutta-percha tree. From the first specimen of leaves which had been sent to England several years previously it was seen that it belonged to the natural family of Sapotaceæ. The many species of this family are scattered over the tropical and semitropical world, and are distinguished by the curious property they all possess of secreting a milk or latex in the inner layers of the bark. When the bark is cut or bruised and the capillary sacks and tubes, which contain the latex, are ruptured, it flows out with greater or less abundance, according to the species of the tree. What part this secreted milk plays in the plant economy has not yet been determined, but the essential fact has been established that this product is discarded by the tree in its dead leaves and bark, and that the bark of the live tree can be tapped and the latex removed with no apparent injury to the tree.

As has been stated, it was in 1847 that specimens of the flowers and fruit finally reached London and the complete botanical determination of them made, which resulted in giving to the tree the name of Dichopsis gutta Benth. et Hook., fils. A few years later the Dutch botanist Burek pointed out the fact that as early as 1837 Padre Blanco had given the name of palaquium to this genus of Sapotaceæ, and accordingly most botanists have adopted the name palaquium for these wonderful



MORO SAILBOATS, "VINTAS."

species[a] of forest trees, which produce the bulk of all the gutta-percha used in commerce.

As the demand for gutta increased and the trees of the species *Pal. gutta* became scarcer and more difficult to reach, the native collectors were not slow in finding other species that produced gutta-percha, though of an inferior quality. Chief among these *Pal. treubii* Burck, *Payena leerii* Benth. et Hook. fils, and *Mimusops balata* Gaertner fils are the best known. Many other species have been found in Sumatra, Borneo, Celebes, and the Malay Peninsula, but what part they play in the production of the gutta-percha of commerce has not yet been determined.

The accompanying photographs will show some of the resemblances and differences between the species above mentioned. The trees of the genus *Palaquium* are among the largest of the tropical forest, and are generally to be noted by the brilliant green color of their leaves above and the golden to copper-brown shimmer below.

The following general description of the botanical characteristics of *Palaquium* is made by Mr. Merrill:

PALAQUIUM BLANCO 1837 (DICHOPSIS THWAITES).

Usually large trees with rusty-tomentose branchlets, leaves obovate or oblong, acute or obtuse, petioled, coriaceous glabrous beneath, or densely rusty-tomentose. Flowers fascicled, axillary on the naked branches below the terminal leaves. Calyx lobes 6, in two series, corolla lobes 6. Stamens 12 to 18, attached near the base of the corolla. Ovary 6 celled. Fruit fleshy, ellipsoid, or ovoid, 1 to 2 seeded. Seeds exalbuminous cotyledons, large, fleshy.

In regard to the species *Mimusops balata* mentioned above, it is to be noted that it is the only representative so far known of gutta-percha producing trees in the Eastern Hemisphere. It was discovered in the Guianas in 1857 and contains a fairly good grade of gutta-percha. Obach designates it in his description as a substitute for gutta-percha in all its chemical and physical characteristics. Though of an inferior grade to that coming from *Palaquium gutta*, it may well be classed among the rest of the *Palaquium* and *Payena* species, furnishing second and third grade gutta-percha.

The gutta-percha trees of the Philippines embrace both *Palaquium* and *Payena* species, and while their complete determination or identification is still unfinished, those which produce the gutta-percha of commerce have been located, and their final identification is only a matter of collecting more complete herbarium material.

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[a] Of late years the Dutch and English botanists in the Orient have been inclined to divide *Pal. gutta* into three species, viz, *Pal. gutta*, *Pal. oblongifolium*, and *Pal. bornense*, but as no certainty of differentiation yet exists, while the gutta-percha from all is the same, they may for the present be all classed under *Pal. gutta*.

The following table, No. 5, gives the species at present known. Those marked (*) probably furnish the largest part of the gutta-percha exported from the southern islands.

Table No. 5.

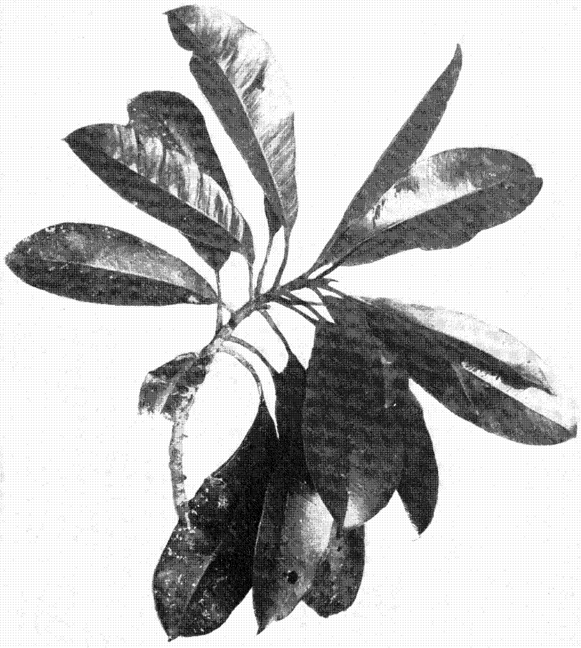
Species.	Local name.	Locality.	Botanical description.
Leaves rusty, tomentose beneath:			
Pal. latifolium Blanco	Polacpolac or alacap.	Luzon to Mindanao.	Leaves obovate, obtuse, 10 to 30 cm. long, 5 to 15 cm. wide. Nerves, about 15 pairs.
Pal. oleiferum Blanco	Alacap or daracan.	Luzon	Leaves obovate-lanceolate, 10 to 25 cm. long, 6 to 10 cm. wide, acute. Nerves, about 15 pairs, closely related to the preceding.
Pal. barnesii Merrill	Nato	Masbate	Leaves obovate, obtuse, thin, 12 to 15 cm. long, 7 to 8 cm. wide. Nerves, 11 pairs.
Pal. ahernianum Merrill*	Calapia	Mindanao	Leaves ovate or obovate, obtuse or acute, 12 to 14 cm. long, 5 to 6 cm. wide. Nerves, 15 pairs.
Leaves glabrous beneath:			
Pal. celebicum Burck*	do	do	Leaves lanceolate, acute, 15 to 20 cm. long, 5 to 6 cm. wide. Nerves, 12 to 14 pairs.
Pal. cuneatum Vidal	Dulitan	Luzon	Leaves ovate, lanceolate or obovate, acute or obtuse, 5 to 7 cm. long, 2 to 3 cm. wide. Nerves, 11 to 12 pairs. Indistinct.
Pal. gigantifolium Merrill.		Tayabas	Leaves obovate, 50 cm. long, 20 cm. wide. Nerves, 20 to 24 pairs.
Pal. luzoniense Vidal	Bogalañgit	Luzon	Leaves ovate, acute, or obtuse, 10 to 14 cm. long, 4 to 6 cm. wide. Nerves, 12 pairs.
Pal. mindanaense Merrill.*	Calapia	Mindanao	Leaves ovate, acute, 9 to 12 cm. long, 4 to 5 cm. wide; petioles 3 cm. long. Nerves, 14 to 16 pairs.
Payena leerii Berth. and Hook.*	do	Tawi-tawi	Leaves ovate or ovate oblong, 5 to 10 cm. long, 2.5 to 4 cm. wide, cuneate at the base, short, acuminate at the apex.

GEOGRAPHIC DISTRIBUTION.

As previously stated, the first gutta-percha trees were reported from the island of Singapore, and, in fact, within a few miles of the city itself. When the substance became a marketable article these trees were the first to fall and all of the island was soon devastated. The explorations, from Singapore as a center, were made in all directions and with remarkable success. All of the forest of the southern half of the Malay Peninsula gave large yields, as well as the islands of the Rhio Archipelago, Borneo, and most of Sumatra. However, from all of the data which have been gathered from native sources, as well as from the information collected by many Dutch, English, and French explorers, it appears that the area of distribution of the *Palaquium gutta* trees is sharply defined. Beyond the sixth degree north on the Malay Peninsula the trees became scarce or ceased altogether; on the northern end of Sumatra they are likewise lacking. Java, bordering close on Sumatra, contained none, and Celebes, to the east of Borneo, was found to be equally destitute. Reference to the map will show the area of distribution of the *Palaquium gutta*, which is practically included in a parallelogram inclosing the above-mentioned peninsula and islands. This area included some 450,000 square miles of land, of which only a very small per cent is or ever was covered by gutta-percha trees.

Obach, in his celebrated book on gutta-percha, practically limits the area of gutta-percha production for the entire world to this small territory. While this statement is probably true, so far as the gutta-percha from *Palaquium gutta* is concerned, we have already seen that the area of distribution of the other or inferior species is extended eastward so as to take in the Philippines, and the same is also true of Celebes, Java, and the northern half of the Malay Peninsula.

The number of gutta-percha producing species in the Philippines has already been listed, and some of the localities given where they have been found. Attention is again called to the distributing of these localities, extending so far north as well as south, and it can be confidently expected that when the forest surveys are completed nearly all of the islands will be found to contain some species in more or less abundance.



LEAVES OF PALAQUIUM GUTTA BURCK, GROWN IN BOTANICAL GARDEN, SINGAPORE.
FURNISHES FIRST GRADE GUTTA-PERCHA.

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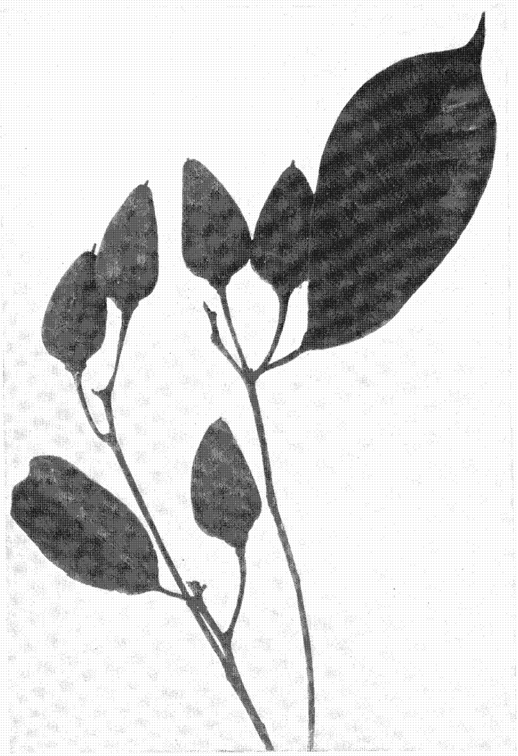

LEAVES AND FRUIT OF PAYENA LEERI BENTH. ET HOOK, FROM BUITENZORG, JAVA. FURNISHES SECOND GRADE GUTTA-PERCHA.

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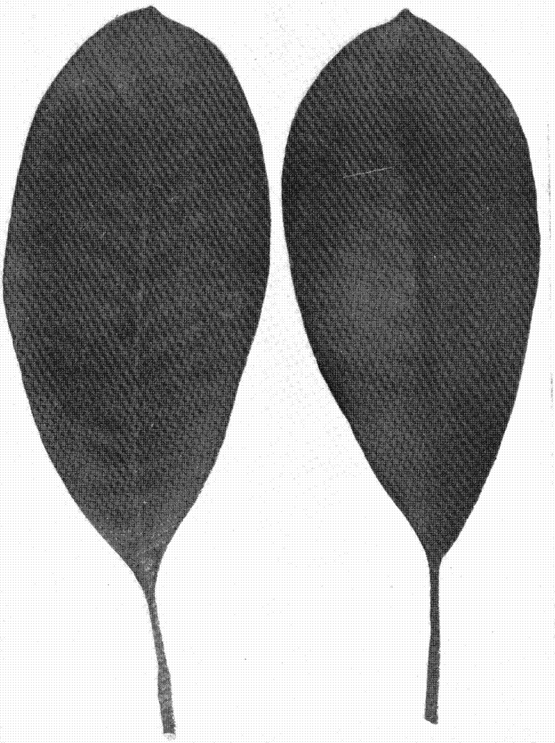
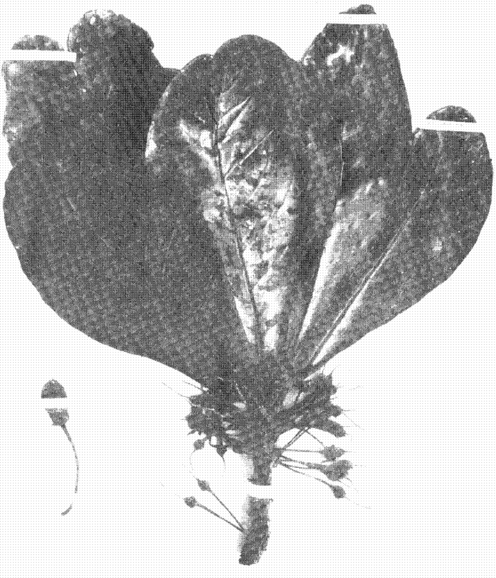


LEAVES OF PALAQUIUM TREUBII BURCK, GROWN AT BUITENZORG, JAVA. FURNISHES SECOND-GRADE RUBBER.



PALAQUIUM LATIFOLIUM BLANCO, PROVINCE OF TAYABAS, LUZON.

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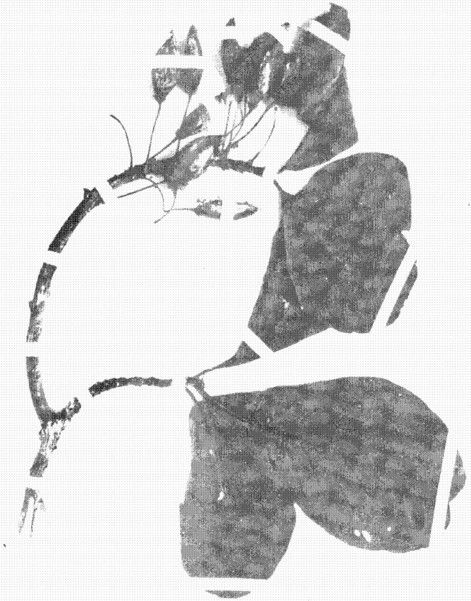

PALAQUIUM BARNESII MERRILL, ISLAND OF MASBATE.

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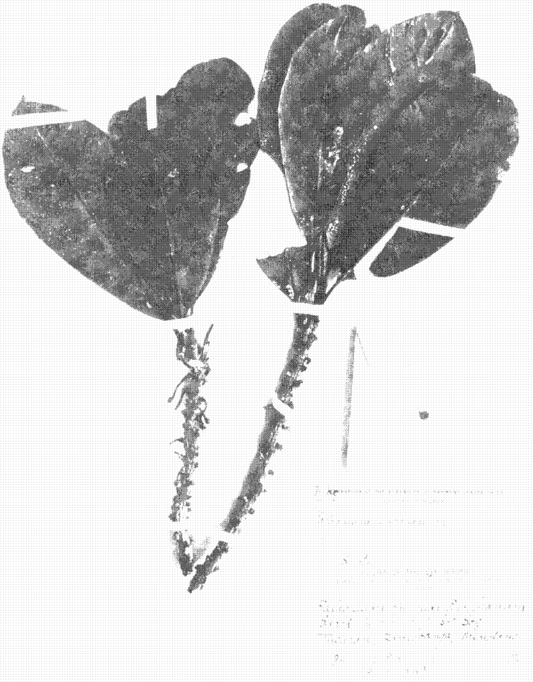
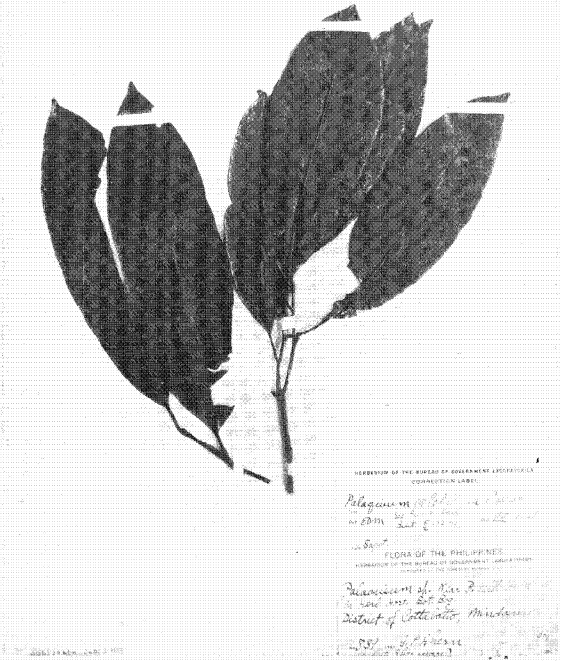
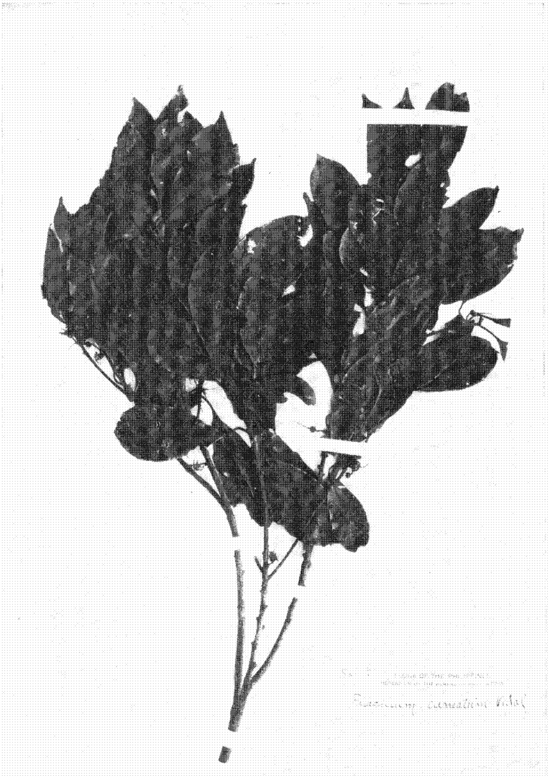


PALAQUIUM AHERNIANUM MERRILL. TUCURAN, DISTRICT OF ZAMBOANGA, MINDANAO.


HERBARIUM OF THE BUREAU OF GOVERNMENT LABORATORIES
CORRECTION LABEL
Palaquium
EDM
Sapot
FLORA OF THE PHILIPPINES
HERBARIUM OF THE BUREAU OF GOVERNMENT LABORATORIES
District of Cottabato, Mindanao

PALAQUIUM CELEBICUM BURCK, DISTRICT OF COTTABATO, MINDANAO.



PALAQUIUM CUNEATUM VIDAL, PROVINCE OF TAYABAS, LUZON.

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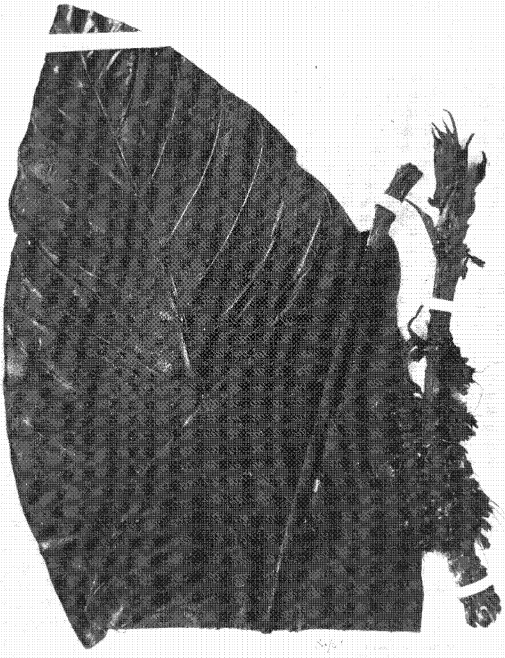

PALAQUIUM GIGANTIFOLIUM MERRILL, PROVINCE OF TAYABAS.

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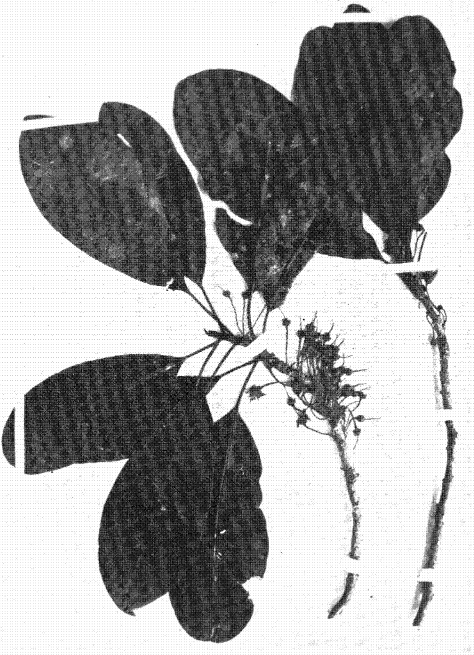
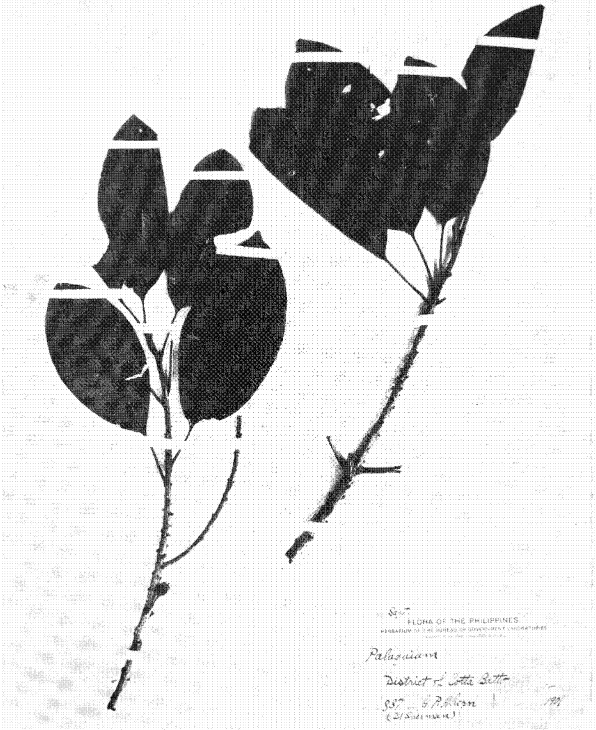


PALAQUIUM LUZONIENSE (F. VILL) VIDAL, PROVINCE OF TAYABAS, LUZON.



PALAQUIUM MINDANAENSE MERRILL, DISTRICT OF COTTABATO, MINDANAO.

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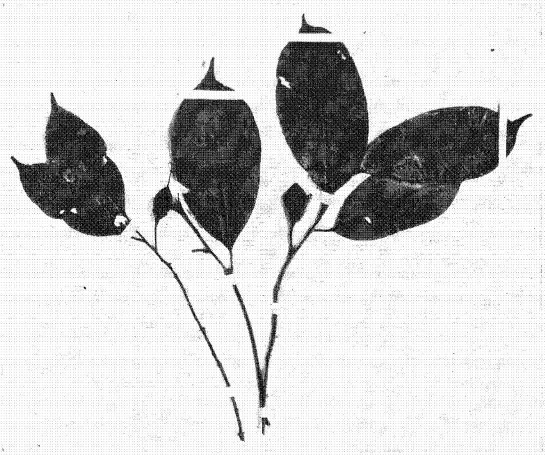

PAYENA LEERII (T. ET B.) BENTH. ET HOOK, TAWI TAWI.

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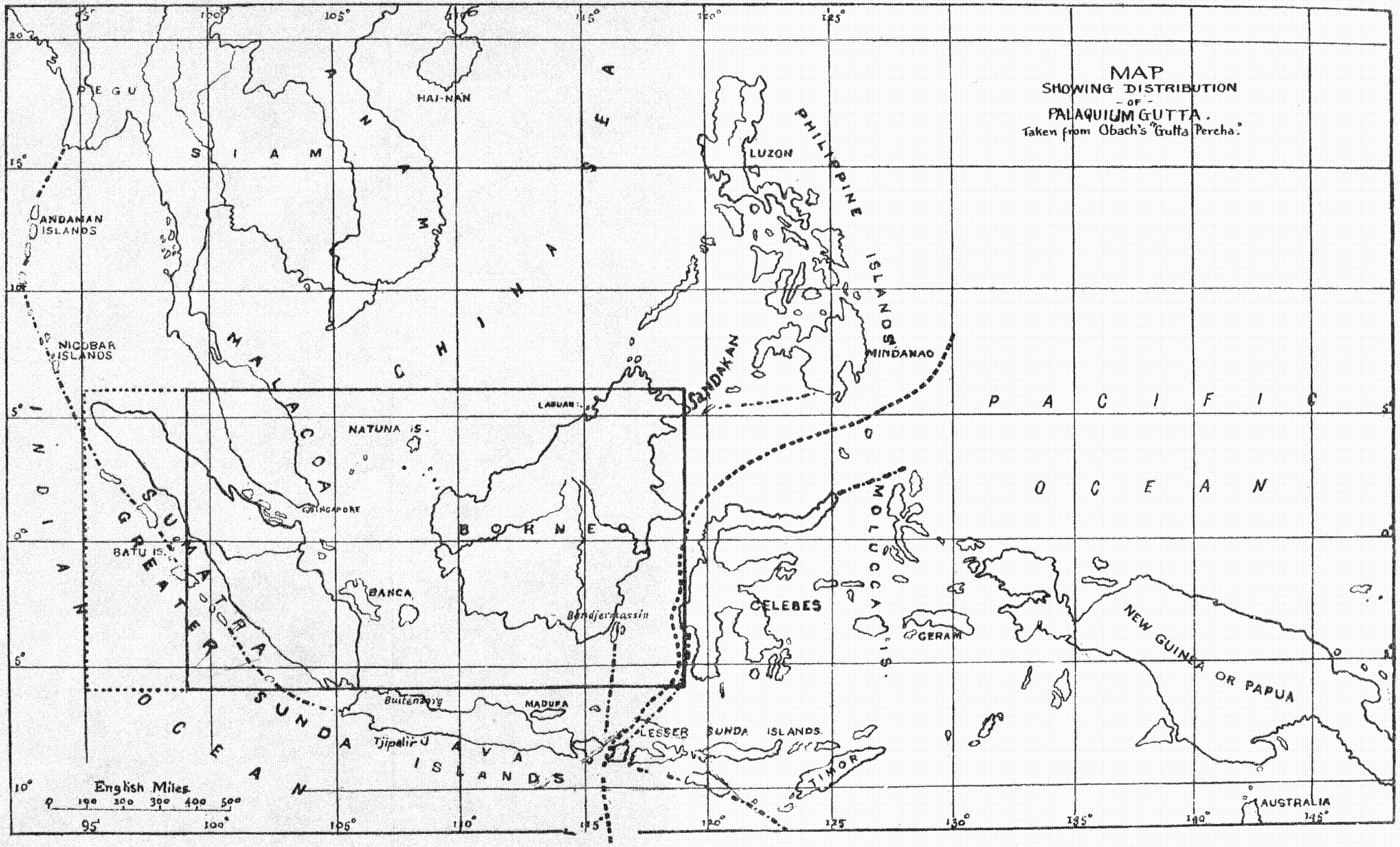

MAP
SHOWING DISTRIBUTION
- OF -
PALAQUIUM GUTTA.
Taken from Obach's "Gutta Percha."
PEGU
SIAM
ANNAM
HAI-NAN
CHINA SEA
ANDAMAN ISLANDS
NICOBAR ISLANDS
MALACCA
NATUNA IS.
SINGAPORE
BORNEO
LABUAN
SANDAKAN
LUZON
PHILIPPINE ISLANDS
MINDANAO
PACIFIC OCEAN
INDIAN OCEAN
SUMATRA
GREATER SUNDA ISLANDS
BATU IS.
BANCA
Bandjermassin
CELEBES
MOLUCCA IS.
CERAM
NEW GUINEA OR PAPUA
Buitenzorg
MADURA
Tjipelir
JAVA
LESSER SUNDA ISLANDS
TIMOR
AUSTRALIA
English Miles
0 100 200 300 400 500
95° 100° 105° 110° 115° 120° 125° 130° 135° 140° 145°
20° 15° 10° 5° 0° 5° 10°

Map No. 1

M70U

Owing to the limited extent of the areas where gutta-percha trees have so far been found on most of the islands, the regions which produce gutta-percha for the market at the present time are limited to the islands of Mindanao and Tawi-tawi. The accompanying map is arranged to show the places where gutta-percha species have been found as well as to give some idea of the size of the districts producing the gutta-percha now being exported. The exact or even approximate extent of these areas is difficult to calculate. Much has not yet been explored, and the information derived from the natives is vague and contradictory. The areas on the map are given conservatively and are known to produce gutta-percha at the present time. Other territories will probably become known as our intercourse with the wild tribes inhabiting these regions grows more friendly and open.

List of towns and forest regions from which gutta-percha is exported to Singapore.

Central point for collection and exportation of gutta-percha.	Point of collection of gutta-percha from the various forest regions.	Name of forest regions from which gutta-percha is collected.
Cotabato	Tukuran and Dinas	Dinas-Subano.
		Camalarang.
		Labangas.
		Tukuran.
	Malábang	Laguna de Lanao.
		Baras.
		Liangan.
		Segayan.
	Clan, Surangani, and Binang	Tagabuli.
		Manobo.
		Bilan.
		Binang.
	Reina Regente and Salaya	Dama Balao.
		Matingauanan.
		Talayan.
Zamboanga	Baluan, Curuan, Talucsangi, Puerta Sta. Maria, Dapitan, Misamis.	Western and northern Subano.
Jolo (Sulu)	Transshipped from Davao, Cotabato, Zamboanga, or Siassi.	Tawi-tawi.
Bongao	Siassi, Balambing, Buan, Dajapatan	Do.

METHODS OF COLLECTING AND MARKETING.

The question of what is the best method for collecting gutta-percha has troubled owners and dealers from the beginning and a satisfactory answer is still lacking. The trees are in the tropical forest regions of the Malay Archipelago, Borneo, and the Philippines, which are inhabited by the wildest pagan tribes only. These natives are the natural gutta-percha collectors, and as a matter of fact have done all the collecting since the beginning. They evolved a method which answered their requirements very satisfactorily. As might be inferred, they wished the maximum yield of gutta-percha from each tree with the minimum expenditure of work or time. That the method was extremely wasteful did not concern them, nor were they bothered over the prospect of a bankrupt future.

The method which is still in vogue from the westernmost part of Sumatra to the easternmost point of Mindanao is, with various minor modifications, practically as follows: The tree is first cut down and the larger branches at once lopped off, the collectors say, to prevent the gutta-percha milk from flowing back into the small branches and leaves. As has been previously stated, the milk or latex is contained in the inner layers of the bark and leaves in small capillary tubes or ducts (see photograph, fig. 27). To open these so as to permit the maximum amount of the milk to escape, the natives cut rings in the bark about 2 feet apart along the entire length of the trunk. The milk as it flows out is collected in gourds, cocoanut shells, large leaves, or, in some districts, in the chopped-up bark itself, which is left adhering to the tree for the purpose of acting as a sort of sponge. After one or two hours, when the milk has ceased to flow, the contents of the receptacles are united and boiled over a fire for the purpose of finishing the partial coagulation. The warm, soft mass is then worked with cold water until a considerable amount is mechanically inclosed. To further increase the weight, chopped bark, stones, etc., are added, and the whole mass kneaded into the required shape with most of the dirt on the inside.

The gutta-percha gathered in this way well repays the amount of work expended. The two vital defects of the method are:

(1) The method is very wasteful, the yield from each tree being a small proportion of the total amount. What this per cent is has been investigated by scientists, with

the result that the figures differ widely. Remembering that the gutta-percha milk is contained in capillary ducts and tubes, it will be seen that a considerable amount can not flow out on account of capillary attraction, no matter how much cutting is done. It very seldom happens also that a tree falls in such a way that all its trunk is so exposed as to admit ringing on all sides. As a general thing from one-third to one-half of it is inaccessible to the process of ringing, and all the milk within it is consequently lost. Even the larger limbs are not deemed worth ringing and consequently all the milk in them and in the leaves also goes to waste. To this must be added the considerable quantity spilled on the ground through carelessness and lack of enough receptacles for every cut or bruise from which the milk flows.

The method employed to find what percentage of gutta-percha has been removed from a tree by the native collectors was to determine the per cent of gutta-percha remaining in a given area of the bark, multiply this by the total bark area of the tree and adding 15 per cent of this amount for that contained in the bark of the branches and in the leaves.

The amount which the native collectors secure from the average full-grown tree apparently varies according to the species, season, personnel of collectors, etc. Most authorities place the amount per tree at one-fourth of a pound. The director of the botanical garden in Penang secured 1½ pounds of clear gutta-percha from a large tree (*Pal. gutta*) estimated to be 60 years old. Ury obtained somewhat over 2 pounds from a *Palaquium gutta* tree at least 100 years old, and 2½ pounds from one of an inferior species.

Burck made some extended experiments in Sumatra and secured an average of less than 1 pound from full-grown trees, while Serullas in Sumatra obtained almost 1 pound from a giant tree. Trees of inferior grade have been found to give as high as 8 pounds. Probably the best average obtainable is 3 pounds. In the Tiruray district of Mindanao I secured 1 pound of clean gutta-percha from a tree 135 feet high and 5 feet 4 inches in circumference at the base. The work was carefully done by the natives. Taking a measured amount of the bark of this tree after no more gutta-percha could be collected by the native method, and extracting all of the gutta-percha that it still contained, it was estimated that after collection there still remained 6½ pounds of gutta-percha. Taking into consideration the fact that had the tree not fallen in such a way as to leave almost all of the trunk propped high enough above the ground to allow the milk to be extracted from the bark on the under side, the amount extracted would undoubtedly have been much less, or, in other words, ten times more gutta-percha would have been left to rot with the tree than was taken from it by the natives. Other investigators have secured figures as large as these, and some found that forty times more gutta-percha was left behind than was secured by the careless collectors.

(2) It leaves the future unprovided for. It has been seen that the invariable practice of the native collectors is to fell the tree in order to extract the gutta-percha. In some cases it has been reported that the stumps stool afterwards and in course of time produce new trees, but it can be safely asserted that this is the exception and not the rule. Of those I have found cut down in the Philippines none have ever stooled, though in one case I saw some of the roots of the stump alive long after the felled tree was well advanced towards decay.

It is fortunate that only the full-grown trees contain enough gutta-percha to repay the work of felling, ringing, etc., otherwise the complete extermination of the gutta-percha forest would only be a matter of a year or so. On the other hand, the felling of all the trees old enough to bear seed works to the same end with a somewhat longer time limit.

THE MARKETING OF GUTTA-PERCHA.

Having been collected and put in marketable shape, it is carried in baskets on the back of the collectors to the nearest waterway and thence taken by boat to the most accessible town, where, applying the description to the Philippines, it is exchanged for barter to some Moro, Chinese, or Filipino merchant (commerciante) living there for the purpose of dealing in all kinds of native products. From here it is shipped to one of the ports doing an export trade with Borneo and Singapore. The entire gutta-percha trade is practically in the hands of the Chinese in the latter city, and they guard the secrets of boiling, working over, mixing, adulterating, and cooling the gutta-percha for European markets most zealously. All who have tried to investigate their methods agree that there is no connection between the various grades and the different tree species, and that pure gutta-percha from the species *Palaquium gutta* is no longer found on the market unmixed with inferior grades.

Strangely enough, I was unable to find in Singapore any statistics regarding the importation of Philippine gutta-percha. The Chinese dealers denied receiving any, and beyond a few piculs noted in the annual import statistics, no mention of it was found anywhere. I afterwards ascertained that the gutta-percha first goes to Sandakan and Labuan, in British North Borneo, and is there transshipped to Singapore, entering as North Borneo gutta-percha.

Unfortunately, the amount collected for exportation can not be given with any degree of accuracy, as the export statistics include gutta-percha with all other gums. It is known, however, that the amount reaches into tens of thousands of pounds.

LAWS REGULATING COLLECTING AND SHIPPING.

Considering the almost lawless way in which gutta-percha is collected and marketed, it is pertinent to review briefly the few steps taken towards legislating on the subject. The English long ago realized that the gutta-percha forests of the Malay Peninsula were doomed to destruction unless radical measures were taken to change the method of collecting. The first law passed was to prohibit the felling of trees in order to collect the gutta-percha. As the law never penetrated to the wild tribes of the interior, where the collecting was done, it was not effective. As a surer method of stopping the destruction, a second law was passed which prohibited the exportation of gutta-percha from coast towns in the Federated Malay States in which the English could, of course, exercise personal supervision. The result was that the exportation from those places ceased promptly, but the felling of trees did not stop, the export simply traveling northward by overland routes until it was outside of English jurisdiction, and from there it was shipped to Singapore. I can not find that anything effectual has been accomplished by the English nor by the Dutch authorities in Sumatra and Borneo toward remedying the difficulty. It seems to be generally realized at last that wild natives can not be prohibited from doing things where there is no law nor show of authority. Certainly they will not cease felling gutta-percha trees until some one can show them an easier method for collecting the same amount or more of the material, so long as gutta-percha has a market value. The English had the true idea when they took away its market value through prohibiting exportation. The only trouble was that the Malay States are on a peninsula and not an island. This law, if applied to the Philippines, might succeed better by reason of their geographical situation, but so far nothing of this kind has been tried here. As soon as the forestry bureau was established, in 1899, the felling of gutta-percha trees was prohibited. Rules and regulations were provided for tapping the bark of the tree with a bolo in such a manner as to allow the milk to be secured without killing the tree. As the amount of gutta-percha obtained by this process was much less than that secured from felling the tree, while the labor was fully as great and was dangerous besides (some trees being 70 feet to the first limb) the wild natives never practiced this method, nor did they ever hear of it, and all the gutta-percha so far exported has been at the expense of so many trees killed.

Islands such as Mindanao and Tawi-tawi can not stand this for any length of time, and already the gutta-percha trees have entirely disappeared from the vicinity of the coast regions and of the large rivers. According to the forest surveys made so far in the islands the average number of trees of 1 foot in diameter is between 40 and 50 per acre, and, considering the large number of species found in the forests, the number of trees of any one species is generally placed at four or five. With this liberal allowance the forest acreage of the southern islands will probably supply gutta-percha, at the present rate of cutting, for three or four years longer, but not for more than that.

It must not be supposed that scientific investigation has not been directed toward solving this vexed question of securing gutta-percha in paying quantities without killing the trees, but before describing the results of this work, the chemical and physical characteristics of gutta-percha, as well as the prices to be realized for the same, must be considered, in order to demonstrate the difficulties to be overcome.

GRADES AND PRICES.

The prices governing the sales of all grades and kinds of gutta-percha in Singapore, the chief market of the world, seem to be most arbitrary and uncertain. As a general thing they have increased continuously and steadily since the beginning of the industry.

Formerly, the different kinds ot gutta-percha were named from the well-known districts or shipping ports from which they came. An attempt was also made to designate the species of tree furnishing the product, and a further distinction was given as to quality. For instance, "Koatei guta merah No. 1" was first grade of gutta-percha from the species *Palaquium gutta* coming from Koatei, while "Pahang white soondi No. 1" was first grade gutta-percha from the specie *Payena leerii* from the Pahang district.

These names and gradings are still kept up as a matter of convenience for cable codes, etc., but their significance is almost entirely lost, certainly as far as any indication of the tree species is concerned, and often as regards the district of production as well. The Philippine gutta-percha, for example, has no grading nor price in Singapore, and probably comes in under Sarawak white, red, etc.

As has been stated previously, the secrets governing the selection, boiling, adulteration, coloring, etc., of the various grades are closed and known to the Chinese exclusively. This is also true in the Philippines, though very little except boiling and cleaning is attempted before shipping to Sandakan.

Most of the Philippine gutta-percha passes through three hands, and the rise in price is quick and decided. My experiences in the gutta-percha districts of Mindanao and Tawi-tawi were to the effect that the wild native collector had to take about what he could get, which was on an average of $10, Mexican, for a picul of 162½ pounds. Money was seldon paid, the usual thing being barter in rice, cloth, copper wire, cheap jewelry, beads, etc. It is needless to remark that the middleman realized a good profit on his merchandise. He in turn carried the gutta-percha to the export towns and sold it to the Chinese at the rate of $40 to $80, Mexican, per picul of 137½ pounds. As this latter amount was the legal weight for a picul, his profits were increased by the additional pounds which he deliberately stole from the ignorant native. The Chinese exporter pays $5 to $7, Mexican, per picul forestry dues (he being the only one of the three with a fixed residence and amenable to forestry regulations) and exports the gutta-percha to Sandakan or Singapore, where it probably brings $100 to $150, Mexican, per picul of 133½ pounds. There is no definite information on this subject, however, as Philippine gutta-percha, as has been stated, is neither rated nor graded in Singapore. A year and a half ago when the best grade of gutta-percha in the Philippines was said by the Chinese of Cotabato to be worth $80 per picul, the following analyses of Singapore gutta-perchas were made by V. Romburgh and Tromp de Haas:

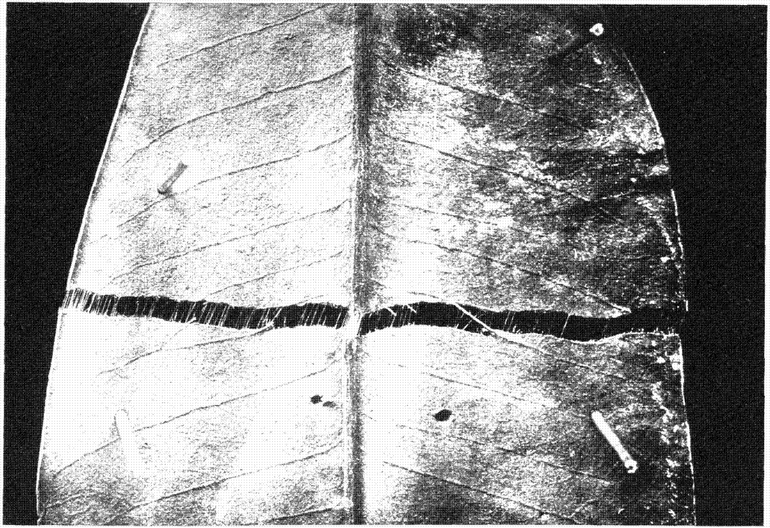
Grade.	Dirt.	Water.	Resins.	Gutta.	Price per picul (Mexican).
Bila (red) Soondi	33.6	7.0	31.4	28.0	$150
Sarowac Soondi No. 2	37.1	6.8	26.5	29.6	135
Pinang gutta Palelo No. 1	2.1	5.8	53.8	38.3	180
Sarawak red Soondi No. 1	19.0	3.9	35.5	41.6	350
Bagan white Soondi No. 1	.7	8.6	36.5	54.2	350
Koatei gutta merah No. 2	21.7	5.1	28.5	44.7	360
Indragiri white Soondi	2.0	4.1	46.2	47.7	370
Sambas white Soondi	1.0	4.4	53.6	41.0	380
Koatei gutta merah No. 1	14.8	3.8	34.8	46.6	500
Pahang white Soondi No. 1	4.2	.5	12.8	82.5	500

According to these analyses the best grades of Philippine gutta-percha may well rank with any of the first four on the list, especially as my chemical and physical tests show the high grade of the gutta in them.

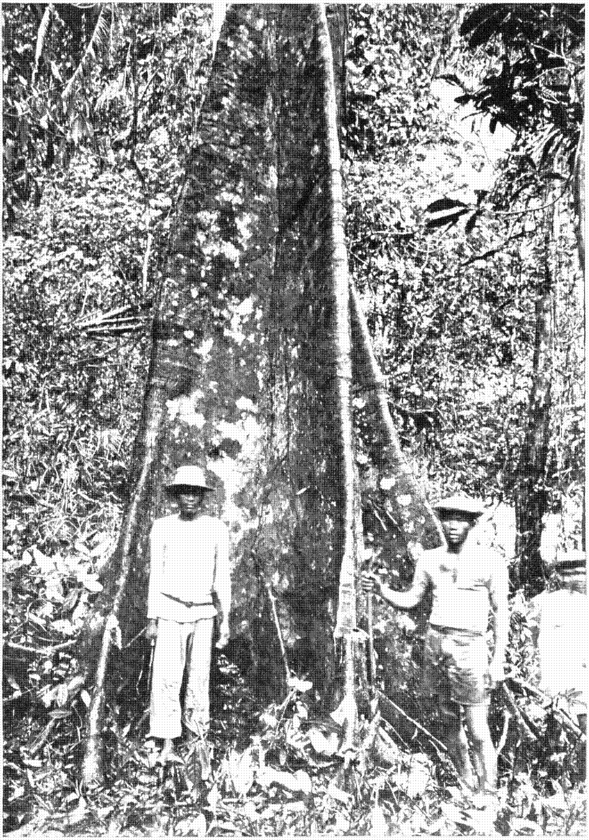
Another example of the difficulty in dealing with the Chinese gutta-percha merchants in Singapore is the experience of an American merchant of Manila who, about this time, took a considerable quantity of the best grade of gutta-percha from Mindanao over to Singapore by way of speculation. He was only offered $8 per picul by the leading merchants there, and it was not until they found out he was not anxious to sell at all, but would ship it to America, that they finally closed with him at $70 per picul. How much the gutta-percha was really worth he never found out.

The evidence then all goes to show that the price of Philippine gutta-percha jumps from about $8 a picul in the mountains, where it is gathered by the wild tribes, to $150 in Singapore. Thus the native collectors get almost nothing, the government about as much, and the Chinese the rest. The Chinese might possibly get even higher prices by exporting direct to London or America, though apparently this has not yet been tried.

It is stated on good authority that the Chinese in all their manipulations for preparing the gutta-percha for the European market go solely by smell, color, toughness, and the softening and hardening test in hot then cold water. At any rate they are certainly very skillful in the work, although careful inspection of the above table, as Van Romburgh points out, would tend to show that their prices were not at all warranted by the analyses. So long as the collecting of the gutta-percha is all in the



GUTTA-PERCHA LEAF (PALAQUIUM GUTTA) ENLARGED, SHOWING FIBERS OF GUTTA-PERCHA PERMEATING THE LEAF INTERIOR.



READY TO FELL A LARGE GUTTA-PERCHA TREE FOR EXPERIMENTAL PURPOSES, DISTRICT OF ZAMBOANGA, MINDANAO.

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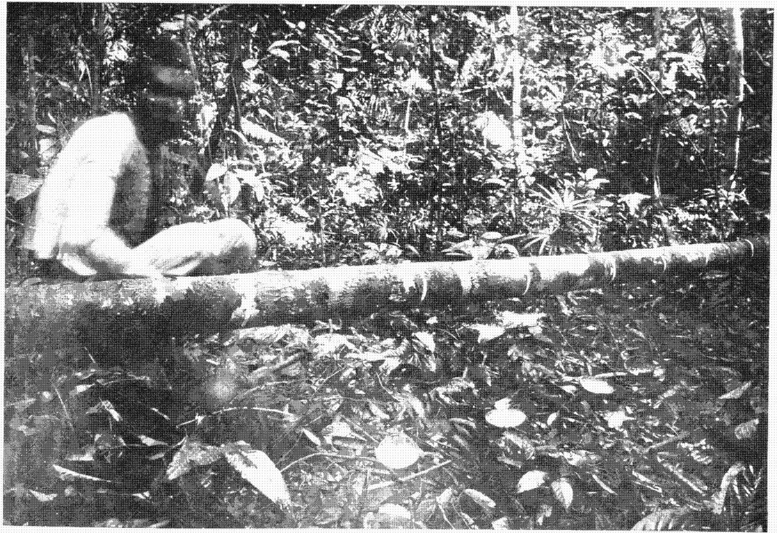
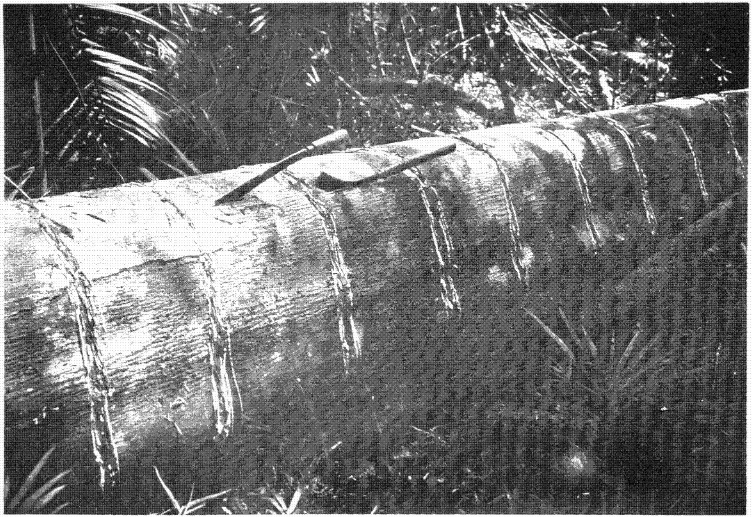
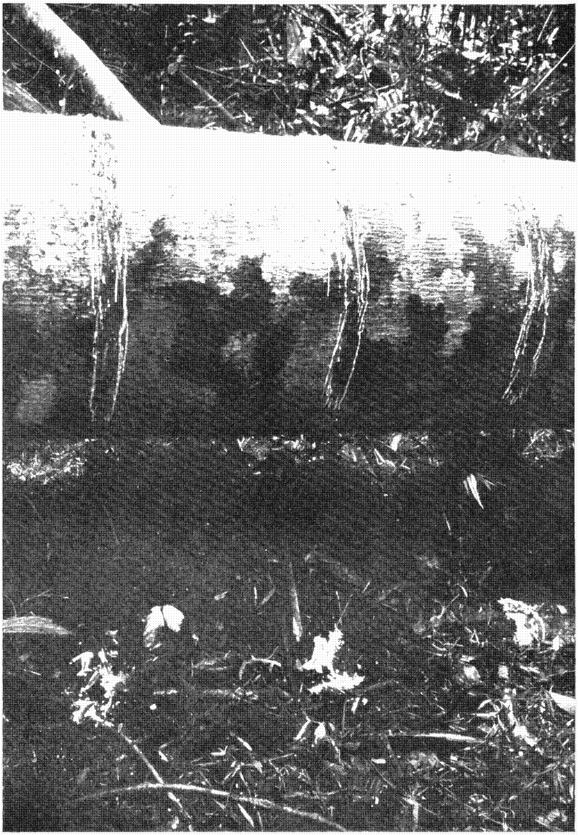


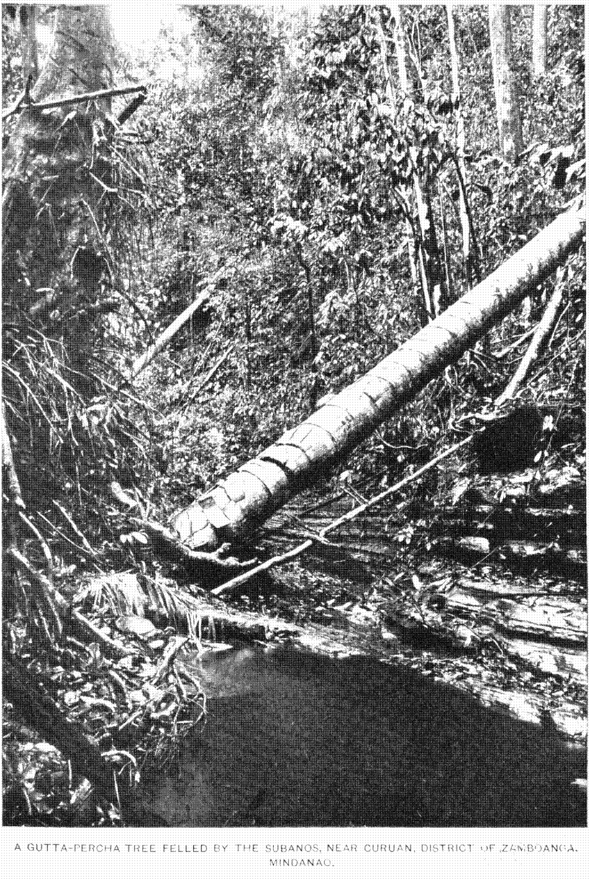
TAPPING A GUTTA-PERCHA TREE SO THAT ALL THE MILK IS COLLECTED IN SHELLS BENEATH. DONE BY MOROS IN TAWI TAWI.



LARGE GUTTA-PERCHA TREE TAPPED SO THAT THE FLOWING MILK IS ALL ABSORBED. TIRURAY DISTRICT, MINDANAO.



A GUTTA-PERCHA TREE TAPPED SO THAT MUCH OF THE MILK IS LOST ON THE GROUND, TUCURAN, DISTRICT OF ZAMBOANGA.



A GUTTA-PERCHA TREE FELLED BY THE SUBANOS, NEAR CURUAN, DISTRICT OF ZAMBOANGA, MINDANAO.

STEM OF GUTTA-PERCHA TREE, SHOWING SCAFFOLDING, ZAMBOANGA.

LARGE GUTTA-PERCHA TREE FELLED AND RINGED, DISTRICT OF ZAMBOANGA, MINDANAO.

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hands of wild natives and the manipulating and marketing controlled by the Chinese, we can not hope to have the gutta-percha trade on a fair business basis. However, as the supply steadily decreases while the demand and prices increase, the attention of Governments and manufacturers will more than ever before be directed to the subject, and perhaps the hoped for relief will come through scientific propagation of gutta-percha trees and scientific collecting of the gutta-percha.

CHEMICAL PROPERTIES.

A chemical examination of the milk or latex above referred to as coming from the gutta-percha trees, upon wounding the bark, shows it to be composed of an emulsion of water and oil in a finely divided state. According to the species of tree, the water varies from a small (best species) to a very large percentage (poor species). A drop of the milk caught on the finger undergoes no apparent change for a few minutes, but by the end of this time a thin rubbery scum can be observed to have formed on the surface. If this be removed a second film will form, and so on until the entire drop has become a small piece of a tough leathery substance. When a fresh drop is worked between the fingers the hardening process or coagulation takes place very quickly, and by boiling or adding certain chemicals, such as mineral or vegetable acids, alum, salt, etc., it takes place almost instantaneously. What the nature of this hardening process is appears to be unknown. The subject will be investigated in this laboratory.

After coagulation sets in (see below) the oily portion becomes hard and tough, while most of the water separates or is inclosed mechanically. Subjecting this hard and tough mass, taken for example from the *Palaquium gutta* species to further examination, it proved to be insoluble in water and very stable against the action of either dilute acids or alkalies. In chloroform or carbon bisulphide it is easily soluble, while ether, petroleum ether, and alcohol dissolve it only in part. By subjecting it to the action of cold alcohol a yellow amorphous resinous powder can be extracted. Hot alcohol further extracts a white crystalline resin, leaving a tough horn-like residue which is easily soluble in chloroform and carbon bisulphide, and can be precipitated from these solutions by alcohol as a white flocculent mass, which, by warming or through pressure, quickly turns to its original appearance. Taking the three constituents of gutta-percha in the order described above, the names fluavil, alban, and gutta were given them by Payen in 1852. Besides the constituents, all gutta-percha was found to contain more or less dirt, coloring matter, and water inclosed mechanically.

The method adopted for making the above analyses is a modification of those used by Obach and Van Romburgh. The former determined first the per cent of water by drying a weighed sample to constant weight on a water bath or desiccator, determining the water by difference. The resins were then extracted with ether and weighed after the solvent had been completely evaporated. The gutta and dirt were thus left and were separated by chloroform, which dissolved the gutta, leaving the dirt to be filtered, dried, and weighed. The chloroform was then evaporated and the gutta weighed.

Van Romburgh in his latest analytical work uses the following scheme: The weighed and finely divided substance is dried to constant weight in an atmosphere of dry carbon-dioxide gas, which fulfills the double purpose of drying and at the same time preventing oxidation. The sample is then dissolved in hot chloroform, thus allowing the undissolved dirt to be filtered off, washed, dried, and weighed. The chloroform solution containing the gutta and resins is diluted with chloroform to 100 c. c. and an aliquot portion taken, evaporated, and dried to constant weight as above. By extracting the residue with hot alcohol or acetone the resins are removed, when the remaining gutta is dried and weighed. The resins are then estimated by difference. Van Romburgh points out that the largest source of error in using this method is due to the evaporation of the chloroform. To avoid this loss and save time the following modifications were adopted:

Dirt.—A fair sample of the gutta-percha to be analyzed was finely divided and quartered down to a small amount. Of this 0.3 to 0.5 gram were taken in a weighed thimble filter and extracted hot in a Soxlett apparatus, chloroform being used as the solvent. When all was dissolved but the dirt this was dried in the filter and weighed.

Resins and gutta.—The chloroform solution is then evaporated to dryness in the same flask (previously tared) dried to constant weight on the water bath in a stream of dry carbon-dioxide gas. After weighing, the contents are extracted with hot alcohol or acetone, when the flask is again dried as before and weighed. The loss in weight equals the weight of resins, and gain of the flask in weight that of gutta.

Water (*estimated by difference*).—Analyses of samples taken from several trees of one species show that the percentages of the constituents vary considerably, being influenced, probably, by the age of the tree, the conditions of its growth (soil, moisture, shade, etc.), as well as by the season at which the sample was taken. For illustration of this two analyses of gutta-percha, known to have been taken from different trees of *Palaquium gutta*, are given to show the large variation in the percentage of gutta. It must therefore be understood that the figures obtained from the analyses of the gutta-percha taken from any one tree will not necessarily represent the exact values for that species. An average from a number of trees is necessary to secure true values. In the same way samples from any commercial grade of gutta-percha may vary quite a little in their percentage composition, the differences, however, generally falling within a well-defined limit.

The "dirt" found in all commercial gutta-percha, as has been stated, may be there unintentionally or have been added with intent to defraud. In either case it consists generally of finely chopped bark, leaves, small sticks, etc. From 2 to 6 per cent of dirt is not only admissible but generally unavoidable, while more than that is looked upon with suspicion. So intimately is some of the dirt mixed with the gutta-percha that even the best machines fail to eliminate the last 1 or 2 per cent.

A certain amount of coloring matter, which exudes from the bark when cut, is also mixed with the gutta-percha milk and colors the resulting gutta-percha. Certain species give a distinctive color to the material taken from them, so it has become a practice of the Chinese in Singapore to boil inferior grades with the bark of the best species, in order to give them the correct color.

Under "resins" are considered the resinous-like substances which with gutta go to form the substance gutta-percha. These resins vary greatly in appearance. In gutta-percha from *Palaquium gutta*, for example, as has already been stated, one is a white crystalline mass, while the other a yellow amorphous powder. In other species they may be oily or brittle, colored or white. Judging from the formulas, $C_{10}H_{16}O$ and $(C_{10}H_{16}O)_x$, which have been given to alban and fluavil, respectively, it might be inferred that these resins are oxidation products of gutta ($C_{10}H_{16}$). Sufficient work has not yet been done on these bodies, however, to make this anything more than conjecture.

Again taking the gutta-percha from *Palaquium gutta*, for illustration, it is found that the 10 to 20 per cent of resins which it contains is not a detriment but rather a decided advantage. Besides adding much to the bulk they are insoluble in water, poor conductors of electricity, and quite stable against the action of air and moisture. In fact, gutta-percha at present prepared for the insulation of submarine cables is composed of one part of resins to every two parts of gutta. When the amount of resin passes this percentage, however, the toughness of the gutta-percha is lessened and other objectionable qualities become apparent. The necessity, then, of knowing the percentage of resin in a given quality of gutta-percha before using it for manufacturing purposes is plainly apparent.

As might be inferred from the preceding, the "gutta" is the principal constituent in gutta-percha. The methods of separating it from the other constituents have been given and its indifference toward dilute acids and alkalis noted. Concentrated nitric acid causes violent oxidation, while sulphuric carbonizes it in a short time. Alkalis, even when concentrated, have practically no action on it. The best solvents for gutta are chloroform, carbon bisulphide, and carbon tetrachloride. From all of these solutions it may be reprecipitated by the addition of alcohol.

If gutta be subjected to dry distillation, isopren, C_5H_8, and kautchin, $C_{10}H_{16}$, distil over as the chief decomposition products, and are identical with the isopren and kautchin recovered from the dry distillation of rubber. Tilden succeeded in changing isopren back again into a rubber-like substance through the action of concentrated hydrochloric acid. As isopren, according to Ipatiew and Wittorf, is methyl divinyl, $CH_2{=}C\ (CH_3){-}CH{=}CH_2$, both gutta and rubber will perhaps be found to be polimerization products of isopren.

The discussion has so far been of the gutta found in the species *Palaquium gutta*. Dr. Eugene Obach, as chemist for a large cable insulating company, made analyses of specimens of gutta-percha from different species of trees as well as from many grades of commercial gutta-percha. In his table of analyses he puts under the name of "gutta" the substance found in each sample, which was insoluble in boiling alcohol but soluble in chloroform. The "guttas" thus found were variously colored from white to dark brown, and possessed different tensile strength from "elastic" and "very strong" to "brittle." Obach thus used certain slight chemical similarities as his criterion of a gutta and neglected, apparently, the wide physical differences which these bodies, as will be shown later, display. Provided there are many kinds of guttas, it is then easily understood that a chemical analysis alone of a gutta-percha will give almost no insight into its value unless accompanied by physical tests of the gutta contained in it.

Before going further with the discussion as to whether chemical or physical tests should decide what is or is not "gutta," attention is called to the various physical properties of these bodies before mentioned. To provide material for these physical tests, they were isolated in considerable quantities from various representative Singapore and Philippine gutta-perchas by means of solvents, and after evaporation were dried in a stream of dry carbon-dioxide gas to prevent any possible oxidation. When heated to the temperature of boiling water they could be easily cut or molded into the necessary shape for performing the following experiments:

Gutta.	Color.	Action toward—			
		Light.		Heat: Softening temperature.	Stress: Tensile strength per square inch.
		Refractive index, 70° C.	Rotation in 0.5 per cent solution.		
				° *C.*	*Pounds.*
No. 1	Light brown	1.5093	−6.75	62	5,262.4
No. 3	Cream white	1.5088	−6.5	60	6,668.15
No. 4	Yellowish white	1.5089	−7.5	61	5,134.7
No. 10	Cream white	1.5076	4.75	56	Brittle.
No. 5	Very light chocolate	1.5093	−6.5	61	6,451.45

EXPLANATION OF TABLE.[a]

The "color" of the guttas undoubtedly comes from the bark of the tree when cut to secure the gutta-percha, for by repeated solution and precipitation the color may be almost entirely eliminated, leaving the gutta only slightly tinted from a cream color to light pink, and pure white when finely divided. It is my opinion that all variations of color are only incidental and not connected with the chemical structure of the gutta itself. The amount of color in the above samples was minimum and not sufficient to have any material effect on the physical properties. The other experiments with light, namely, those given under refractive index and rotation, are employed with great success in the commercial analysis of sugars, oils, fats, butters, etc. This is due to the fact that each chemical individual, providing it is capable of transmitting light, has an index of refraction peculiar to itself, which, for purposes of comparison, must be taken under constant conditions and, provided it is able to rotate the plane of polarized light, a degree of rotation which is also constant. While two chemical individuals may show identity in some one physical property, they can not continue this identity in two or more, so that more than one method was necessary to determine the relationship of the guttas examined by me. Substitution, adulteration, or variation in chemical structure can in this way be easily discovered and determined. Owing to certain mechanical and chemical difficulties encountered in making these determinations on the guttas, the limits of error of experimentation are outside of the differences found between Nos. 1, 3, 4, and 5, but do not include the marked difference displayed by No. 10. In determining the refractive index, an Abbe-Zeiss refractometer was employed, a small amount of a concentrated solution of pure gutta in chloroform placed on each of the prisms and allowed to stand until the odor of chloroform had entirely disappeared. The prisms were then closed, and kept at a temperature of 70° C. until the readings became constant, showing that all chloroform had evaporated. The above figures are the results of many determinations made with carefully prepared samples.

The rotation was determined in chloroform, 0.5 per cent solution being used, because when more concentrated the absorption of light was too great to admit of accurate readings.

The physical tests given in the above table are so diversified as to bring out clearly the extent of resemblance between the various samples of gutta submitted to them. The results show little variation between Nos. 1, 3, 4, and 5; indeed, these samples may be regarded as practically identical in composition. The physical constants appear to be those of a single chemical individual; the refractive index varies only in the third decimal place; the rotation is the same within the limits of only one degree, and the softening points vary only from 60° to 62°. The small amount of resins in the specimens, which it was impossible to remove, would be sufficient to account for even greater variations. No. 1, however, is the best sample used for a standard, and taken from Dichopsis gutta; Nos. 3, 4, and 5 are from the Philippine Islands. It would appear from this that gutta is a chemical individual, identical in all cases, and any substance, such as No. 10, for example, which varies from the properties recorded above should not be designated as such. This opinion is, however, advanced, subject to further confirmation by extended chemical investigation looking toward the determination of the chemical constitution of gutta. In the case of sample No. 10, the substance designated as gutta and the real gutta of No. 3 are very similar in appearance and chemical behavior. In tensile strength, however, they are widely divergent, and this difference is accentuated and not lessened by the other physical tests, for while these latter differences are not so marked, yet they clearly show that all the physical constants of No. 10 differ more or less from all the others, and hence this substance must certainly be different in chemical constitution.

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[a] The results given in this table and some of the explanations appeared in the previous annual report, but as subsequent experience and the completion of botanical data has led me to take up the subject from a different standpoint, they are again appended for the sake of completeness.

The action of heat in softening gutta-percha and making it plastic has previously been used as a test of value. It has been found that the best grades require more heat to soften them than the lower grades. According to the results obtained by me, the inferior grade of gutta (No. 10) also possesses the property of softening at a lower temperature than the superior gutta. The softening point was determined by molding a piece of gutta into the bottom of a glass tube sealed below, placing a sharp-pointed glass rod in contact with the surface, and gradually heating in a bath of sulphuric acid until the point of the glass rod just began to enter the gutta.

The tensile strength, or toughness, possessed by gutta, next to its resistance to sea water, is undoubtedly its greatest merit commercially. Even the inferior grades of gutta-percha are used for objects requiring toughness combined with pliability and strength. In the insulation of a submarine cable great toughness is imperative, for during the laying of the cable it is constantly subjected to great strains from kinking, pulling, rubbing, etc., and when it has reached the ocean bottom, where the pressure is often three and a half tons to the square inch, it must not have sustained a fracture even as large as the diameter of a fine hair, for otherwise the moisture would slowly penetrate to the wires, the insulation would not be complete, and the cable would have to be pulled up and repaired.

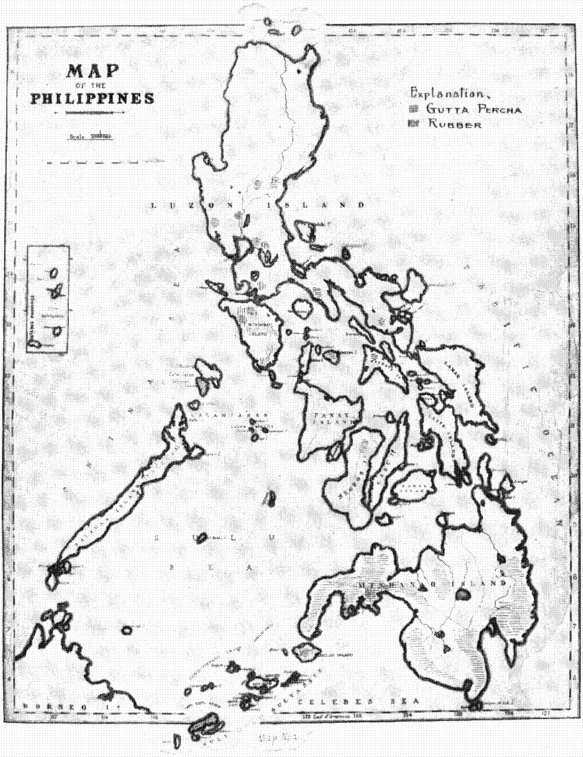
In order that the measurements made might be within the limits of the instruments at hand, only small strands of gutta could be used for testing. To make these strands free from minute air bubbles was well-nigh impossible, in consequence of which the breaking was in most cases brought about by weakness due to this source. The figures, while thus only approximate, are below and not above the true values, and show clearly the enormous tensile strength of my samples. Obach gives a tensile strength of 5,000 pounds for the best gutta-percha, while for the gutta from it he found about 6,500 which closely corresponds to results given above. This also brings out most clearly the excellent quality of the best Philippine gutta-percha.

The results of the combined chemical and physical tests on various samples of so-called "guttas" extracted from gutta-perchas of different origin seem to show that the gutta from the gutta-percha of *Palaquium gutta* has certain well-defined chemical and physical properties. Also that some so-called gutta-perchas contain a substance which chemically resembles to a certain extent, the above-mentioned gutta, but differs widely from it in many of its physical properties. As the gutta from the species *Palaquium gutta* has stood the test of usage for fifty years it is only fair that its chemical and physical constants should be used as the standard of comparison. Until more is known chemically of such substances as I found in No. 10, a chemical analysis will not be sufficient to determine the value of a gutta-percha, but it must be supplemented by physical tests. This laboratory will undertake the task of so determining the chemical properties of gutta and its allied bodies in the hope of discovering a method of chemical analysis which alone can be used to determine the value of any gutta-percha.

SCIENTIFIC PROPAGATION.

As soon as the native collectors made such heavy inroads on gutta-percha forests as to make certain of their serious decimation, if not entire destruction, the various governments having tropical possessions in the East began to take note and make inquiries, but it was not until the last four or five years that the notes became serious or the inquiries anxious. Both explorations and inquiries revealed that the greater part of the Malay Peninsula had lost most of its trees, and that the portions of Sumatra and Borneo which were still productive were in the most inaccessible moun-

Report of the Philippine Commission, 1903. Part 2.



MAP SHOWING DISTRIBUTION OF RUBBER AND GUTTA-PERCHA.

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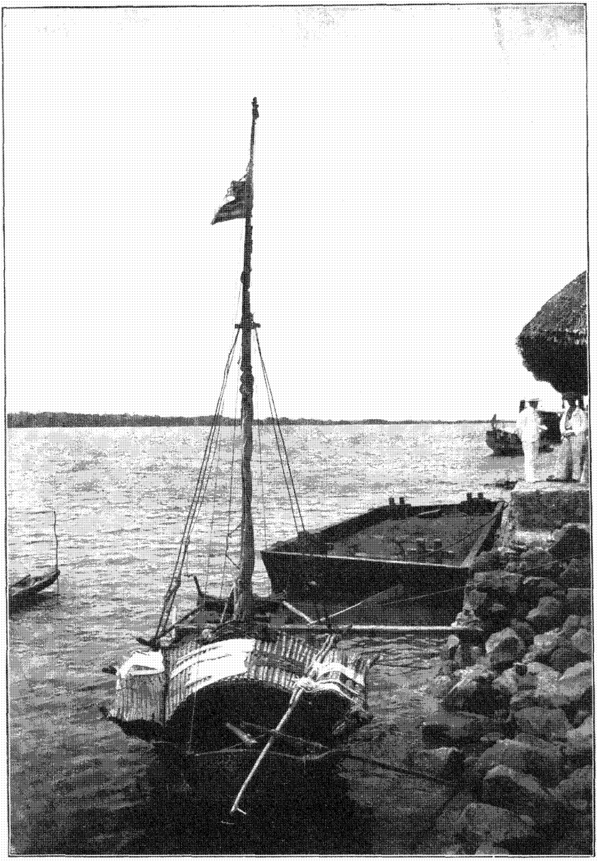
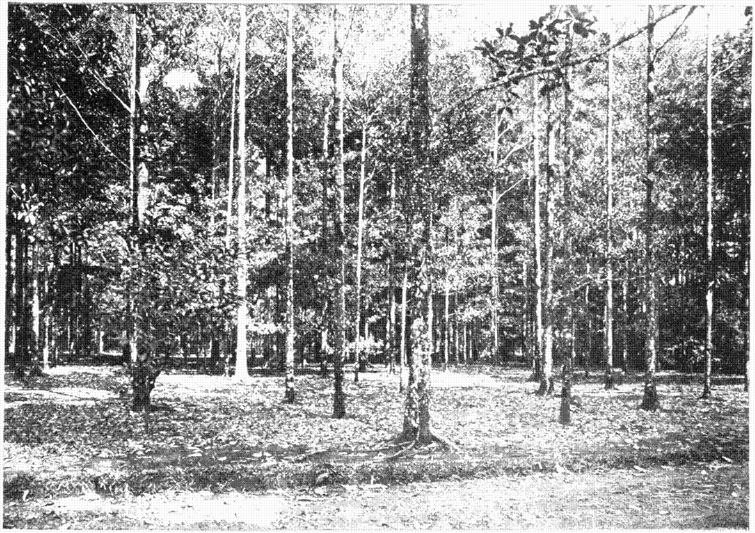
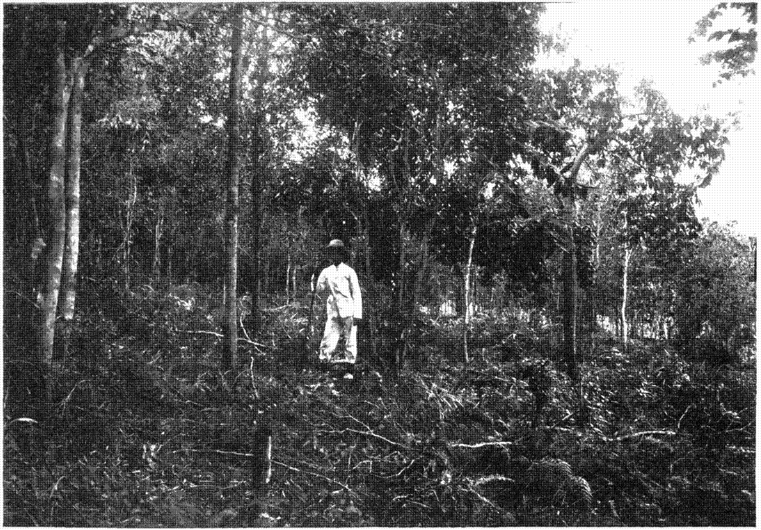


CHINESE TRADING BOAT COLLECTING GUTTA-PERCHA AT PARANG PARANG.



PLANTATION OF GUTTA-PERCHA TREES (PALAQUIUM GUTTA) OF VARIOUS AGES, BUITENZORG, JAVA.



ENGLISH METHOD OF STARTING GUTTA-PERCHA PLANTATION, BUKIT TIMAH, SINGAPORE.

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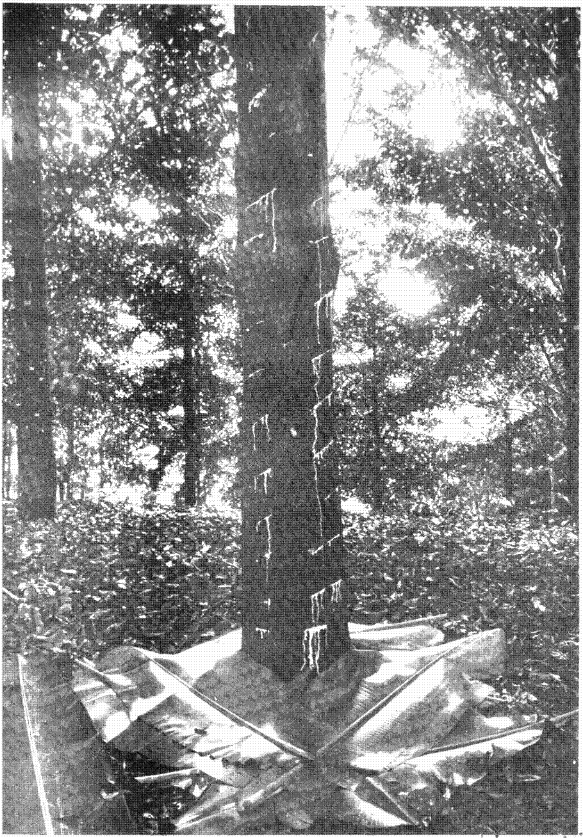
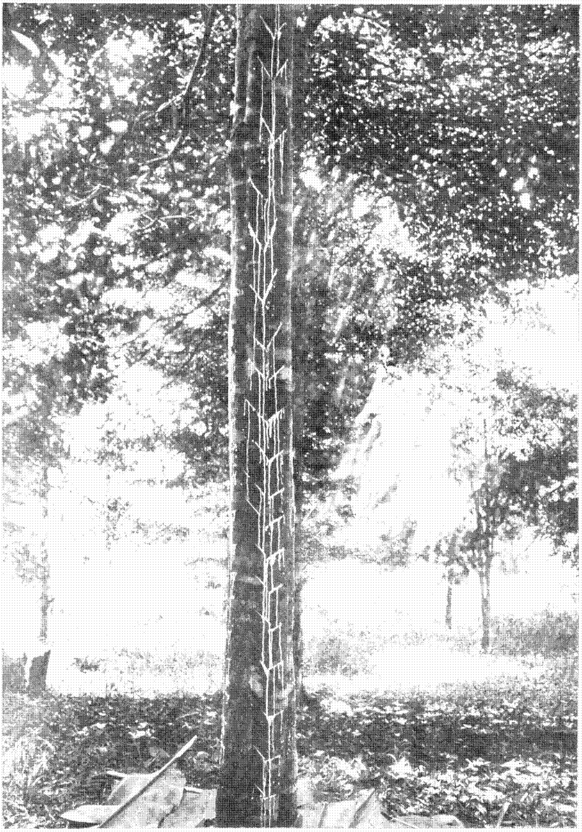
A PALAQUIUM GUTTA TREE GROWING IN THE OPEN, BOTANICAL GARDEN, SINGAPORE, STRAITS SETTLEMENTS.



A TREE OF PALAQUIUM GUTTA JUST TAPPED, TJIPITIR, JAVA.



PALAQUIUM TREUBII JUST TAPPED, TJIPITIR, JAVA.

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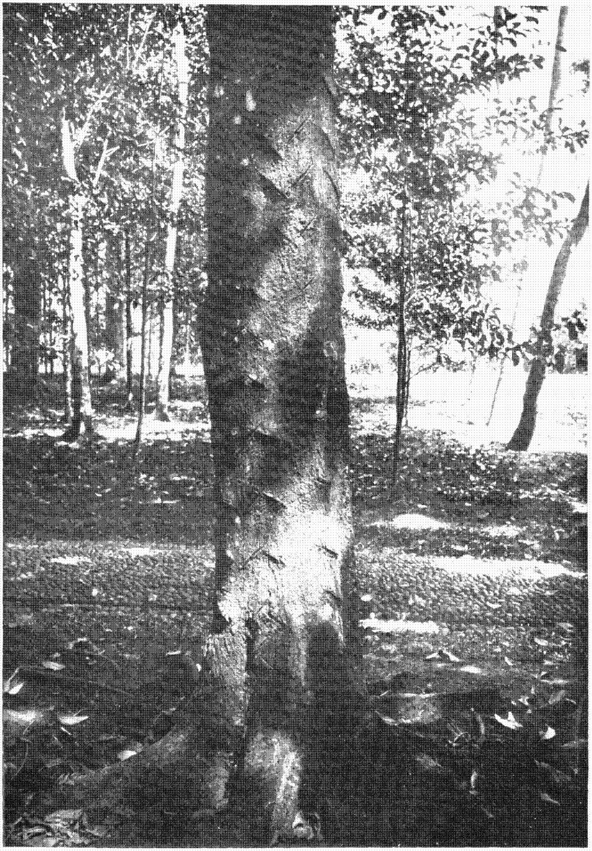


ABSENCE OF DEEP SCARS AFTER SEVERAL YEARS TAPPING, BUITENZORG, JAVA.

tain forests of the interior. So thoroughly had the seed-bearing trees been cleared out of the Malay States that a standing award by Government officials for seeds of the species *Palaquium gutta* were not claimed, though the offer stood for a long time. Von Romburgh, in a very extensive tour of Sumatra and Borneo, made for the purpose of reporting to the Dutch Government the condition of the gutta-percha regions, saw but a few seed-bearing trees, and these, in almost all cases, had been protected by native chiefs.

In the botanical gardens of Singapore, Bukit, Timah, Penang, and Buitenzorg, *Palaquium gutta* trees were growing which had either been protected from destruction or had been planted for a sufficient length of time to be seed-bearing. These formed the nucleus of the gutta-percha nurseries now being planted by the English and Dutch Governments, with the purpose of obtaining reliable information as to methods of propagation, the rapidity of growth, the time necessary for maturing, and above all to furnish material for testing scientific methods for extracting gutta-percha without killing the trees. Owing to the scarcity of seeds everywhere, the Government botanists were obliged to resort to various methods for securing young plants, and their experiments have been along the following lines:

I. *Planting from seeds.*—The fresh seeds are laid in beds of rich earth and allowed to germinate and grow under partial shade. When about a foot high they are transplanted to the future plantation, where the soil may be entirely free from trees, shrubs, or other vegetation (Dutch method) or where small patches of earth have been cleaned and loosened for their reception in a forest of seconary growth, heavy enough only to furnish a light shade (English method). By the Dutch method a light shade is required around each seedling until a vigorous growth is secured. The seedlings are set out about 5 by 5 yards apart, though where it is desired to obtain the largest amount of leaves per acre the space allotted is 4 by 4 yards. No special care seems necessary except to keep them free from weeds. Too much stress, however, can not be laid on the care which should be taken not to break or injure the long taproot of the young plant during the process of transplanting, for any injury to it stunts the growth materially or even causes death. Mr. Curtis, director of the Penang Botanical Gardens, has modified the manner of starting the germination and first growth, by placing each seed in a separate bamboo joint filled with earth. This joint is made long enough to allow the taproot to strike downward undisturbed, and when the time comes for transplanting it can be transferred, joint and all, without any fear of injury, to the place made ready for it. The bamboo is then cracked open and the plant inserted in the ground with almost no disturbance of its roots.

The Dutch Government in Java, having many seed-bearing trees, is now deeply engaged in carrying out a programme which contemplates the planting of some 150,000 seeds annually until at least 1,000,000 trees are growing. This will be done on extensive Government plantations at Tjipitir, Java. The entire management is intrusted to Doctor von Romburgh, director of the Government chemical laboratory at Buitenzorg, who has a corps of assistants intrusted with testing the gutta-percha contained in the seed-producing trees, in order that none but the best stock may be used.

II. *Planting from self-sown seedlings.*—In the forests both of Sumatra and Borneo the natives are still able to find comparatively large numbers of self-sown seedlings of the *Palaquium gutta* species. These, when carefully taken up and transplanted into air-tight boxes provided with glass covers and rich earth, can be packed in large numbers in a comparatively small space and shipped to almost any desired distance. For instance, 60,000 such seedlings were shipped two years ago from southern Borneo to the French Congo, via Antwerp. Those plants transported from Borneo to Singapore in this manner are doing well in the gardens there. The German Government is planning a nursery of such seedlings in the tropical possessions in Guinea.

III. *Slipping by means of marcottage.*—As neither direct slipping nor grafting has ever succeeded with gutta-percha trees, the method called marcottage was tried in Java and the Malay States with some success. This consists in selecting a young straight limb from a large tree, and at the point where the roots are to grow the bark is removed for the length of an inch around the entire limb. The denuded spot is then packed with rich mud which is held in by a coating of cocoanut or other fibers (see photograph). If the mud is kept moist, and only if this is the case can good results be secured, small roots will generally appear in three to nine months, when the limb can be cut off and planted.

The principal gutta-percha plantations now under cultivation and in which much useful and desired experimenting is being done, are located at Tjipitir and Buitenzorg in Java; on Rhio Island, at Singapore, and Bukit Timah on Singapore Island, on Penang Island, and at one or two places in the Federated Malay States. Enough time and work has been spent to demonstrate most conclusively that gutta-percha trees can be raised not only successfully, but also without much trouble or great outlay of money, and all the nations having tropical possessions in the East, except the United States, have made a start toward gutta-percha plantations, but the Dutch are the only ones so far who have gone into it on a grand scale, and unless appearances are deceitful, they will have a monopoly on the plantation of the gutta-percha of the future as sure as they have on the forest gutta-percha of the present day.

SCIENTIFIC METHODS OF COLLECTING.

Modern methods of collecting gutta-percha have advanced along two lines. Needless to say they were not proposed nor carried out by the wild native collectors who are unwilling to discontinue present gains in favor of future returns. It was previously remarked that the gutta-percha is all contained in the bark of the tree and in the leaves. The problem resolved itself into either—

(1) Extracting some of the gutta-percha from the bark and leaves without injuring the tree, or

(2) Felling the tree and securing the gutta-percha from all of the bark and leaves.

To carry out the first proposition a method was devised similar to that used in South America for extracting rubber milk, by which incisions were made in the bark in a slanting direction up and down the trunk (see photograph fig. 40), so cut that the gutta-percha ducts were opened but no injury done to the inside wood of the tree. The milk flowed out to a greater or less extent and coagulated in strings on the bark. After the flow had ceased and complete coagulation set in (one day), the strings of gutta-percha were pulled off by hand, washed in hot water, and pressed into cakes. The advantage of this method was that no injury was done the tree although tapped repeatedly (see photograph, fig. 42.). The disadvantage lay in the fact that only a small per cent of the total gutta-percha in the tree could be extracted at any one time. According to Von Romburgh's latest experiments with plantation trees (*Palaquium gutta*), about 15 to 17 years' old, the yield was 100 grams (nearly one-fifth pound) per tree. The gutta-percha thus secured was of the very best.

In addition to the amount thus taken the leaves, both from the living and dead trees, contain 8 to 10 per cent weight of gutta-percha calculated to the dry leaf. To extract this gutta-percha two processes have been devised.

(*a*) The mechanical one in which the leaf is ground to a powder and then treated with hot water in such a way that the gutta-percha is gradually worked into a compact mass, while the pulp of the leaf is washed away. Up to the present the process has not been perfected, for, although the gutta-percha obtained is of a good quality, the percentage of recovery is smaller than it should be. The largest factory of this kind is being erected near Singapore, and proposes to use the leaves from a plantation of 100,000 trees on the island of Rhio, some five hours from Singapore.

(*b*) The chemical process is carried out on the same lines as the mechanical one, so far as the grinding of the leaves is concerned. The powder is then extracted with solvents and the dissolved gutta-percha recovered either through precipitation or through evaporation of the solvent. The details of the process, as well as the solvents used, are kept secret and no patents for this or the mechanical process have been taken out.

The largest factory producing gutta-percha for the market is located at Sarawak, North Borneo, and is very advantageously situated as regards securing leaves from the surrounding gutta-percha forests. It has been claimed, however, that the factory defeated its avowed object of preventing the destruction of the trees, for the native collectors employed would never risk their lives trying to collect leaves from forest trees over 100 feet high, when they could gather them much easier by felling the tree and collecting a goodly amount of gutta-percha in addition. It thus appears that the supply of leaves must come from a plantation where supervision can be exercised.

The plan of felling the gutta-percha trees of the forest and securing all of the material from the bark and leaves is worthy of serious consideration. In the first place, the trees are surely doomed as long as present conditions obtain. If the native can sell the entire bark and leaves for more than he could get for the gutta-percha which he could extract, he will be tempted to bring them in. A second inducement for this method is the fact that many gutta-percha trees cut down even years previously have still much perfectly sound gutta-percha in the rotting bark, which could also be secured. The process of recovering the substance from the bark is practically the same as from the leaves, and about the same per cent is found there as well. With a yield of 10 to 15 times the present amount recovered from each tree, the gutta-percha market would be relieved at once, and the extermination of the trees put off many years, long enough at any rate to allow plantation trees to take their place.

A large amount of work has been done in the laboratory with the purpose of finding a practical method for extracting the gutta-percha from the bark and leaves of the gutta-percha trees. The process calls for a solvent for the gutta-percha which will dissolve it easily, can be recovered and again used, and above all, has no deleterious effects on the substance.

The result of the experimentation led to a modification of the Obach hardening method for gutta-percha. The process consists in extracting the gutta-percha bark and leaves by means of hot gasoline, the apparatus being provided with reflux condensers. When the gutta-percha has entirely dissolved, the solution is allowed to stand until all of the dirt and most of the coloring matter has settled. The clear supernatent liquid is then poured off and cooled to 10° or 15° below freezing. The gutta, with a small amount of resin, is thereby precipitated, and can be filtered off through cloth bags and dried. The resulting gutta can be further precipitated by redissolving in distilled gasoline and reprecipitating. The filtrate containing the dissolved resins is redistilled, and the recovered gasoline used for effecting further solution of gutta-percha, thus making the process continuous.

The gutta so secured on being warmed can be pressed into any desired form for experimentation. The gutta used in the above experiments was so prepared, and the results of their physical and chemical tests showed them to be unaffected by the process to any appreciable extent. A year's exposure to laboratory fumes has not changed the substance in any way. The accompanying photograph (fig. 43) shows some of the pressed cakes prepared in the laboratory.

It is to be noted that the process gives practically pure gutta and not gutta-percha, the resins remaining dissolved in the gasoline. This is in itself a great advantage as the gutta could be used directly for bringing up the percentage in inferior grades of gutta-percha, and so make them suitable for cable insulation. The commercial value of this gutta has not been determined, but should be rated at about $600 Mexican per picul, judging from the price of the best gutta-percha. In this way 3 piculs of Philippine gutta-percha, at $210 Mexican, will produce 1 picul of pure gutta valued at $600 Mexican, or a gain of $390 for every 3 piculs of gutta-percha (or the equivalent in bark and leaves) handled.

PESTS AND PARASITES.

An instructive bulletin has been issued by Doctor Zimmerman, of the S'lands Plantation, at Buitenzorg, Java. His field of observation covered the large experimental gardens of Buitenzorg and at Tjipitir, where many thousands of gutta-percha trees of various species are now growing. While the same conditions do not obtain there as are encountered in the forest, it is certain that they are as badly if not worse off on account of the multitude of insects of all kinds which are attracted by the other plants of the gardens. In fact, he considers the test a severe one, and his conclusions that there are practically no insect pests that might be considered dangerous is very gratifying. Cattle and goats eat the leaves greedily, and young trees must therefore be protected until high enough to be out of reach.

PART 2.—RUBBER.

HISTORICAL AND DESCRIPTIVE.

Even the shortest outline presenting the subject of rubber in its historical, geographical, botanical, and commercial aspects would be beyond the scope of this report, nor does the part which the Philippines have taken in its production or are likely to take for several years to come warrant anything more than a brief explanation of the present state of the rubber industry in order to better understand the present conditions here and the future possibility of these islands becoming a new center of the ever-increasing rubber industry.

Rubber, or india rubber, as it seems best known in the United States, was discovered by the Spaniards in the second voyage of Columbus. The Indians of Haiti were found playing with rubber balls, which they said were formed from the hardened milk of certain forest trees on the island. In 1755 Don José, King of Portugal, sent several pairs of his boots to South America to be coated with rubber milk. They must have been made satisfactorily waterproof, for the rubber industry has increased from that day to this.

Not alone was the valley of the Amazon found stocked with rubber trees and vines, but new species were discovered in Central America and Mexico as well. In 1798 rubber-producing vines and trees were encountered in southern Asia, later on in central Africa, and by the middle of the nineteenth century almost every tropical country of the world had been searched, and the search has not been in vain.

The number of genera and species—even the families representing the rubber plants—is very large, especially because the production is not confined to trees alone nor to any one country, as is the case with gutta-percha, but includes a large number of vines as well, and its area of production is practically that of the tropical world. While rubber trees predominate in tropical America, Africa and Asia apparently draw their greatest supply from vines. Borneo especially is rich in them to the exclusion of trees. The Philippines were said to contain more trees than vines, but systematic search has so far revealed only vines.

Not until the middle of the last century were the manifold uses to which rubber could be applied well understood and the rubber industry thoroughly established. Statistics show that London imported in 1830 some 46,400 pounds of rubber, and by 1870 this had increased to the enormous amount of 15,211,800 pounds for that one year alone. Since then the consumption has steadily increased, the statistics reading by tons and not pounds, and for 1902 amounted to some 62,650 long tons. London, the former chief center of the rubber trade, has retired in favor of New York. While tropical America in the beginning produced nine-tenths of the rubber supply, it now exports but very little more than one-half of the total amount, India, Burma, Borneo, and Central Africa especially having made giant strides in rubber production. Last year's production for the Malay States, Java, and Borneo was about 1,000 tons. In this was included the amount exported from the Philippines. How much that amount was there is no way of finding out, nor for how long this exportation of rubber has been going on. My investigations in the southern islands convinced me that whatever collecting and exporting has been done concerns the island of Tawi-tawi alone, and in all probability the amount was small. This conclusion is reached because only the natives of Tawi-tawi know of the commercial value of rubber, and also because I found rubber vines very near the coast of Tawi-tawi, a sure indication that the search for rubber has not been very careful nor for a long time.

The Philippine Islands are then practically a new field for the development of a rubber industry. It will be my purpose, therefore, to show—

(1) The species of rubber-producing plants indigenous to the islands and the amount of territory covered.
(2) The grade of rubber produced.
(3) The Philippines as a rubber producing country.
(*a*) Through utilization of natural supply.
(*b*) Through introduction of foreign species.

Reference to the photographs (figs. 45, 46, and 47) will show the two species of vines now known to be well distributed over the islands, both of which produce a good grade of rubber. Owing to my inability to find a vine in fruit or flower, one of them has not yet been determined botanically. Mr. Merrill contributes the following botanical description:

Parameria philippinensis Radlk (*Apocinaceæ*).—An evergreen woody vine, reaching a height of 40 or 50 feet, and a diameter of 1 inch or less. Bark gray, with an abundant milky sap. Leaves opposite, ovate, acute or somewhat acuminate, glabrous, 2 to 3 inches long; nerves four pairs; petioles short. Flowers small, white, fragrant, in terminal panicles. Fruit a long, slender, distantly torulose follicle, 10 to 12 inches long, the swellings over the seeds an inch apart. Seeds one-half of an inch long, brown, coma white, about twice as long as the seed.

Apocinaceæ (genus undetermined, specimen with leaves only, from the island of Basilan).—A very large vine 150 to 200 feet in length, with a diameter of 6 to 8 inches, the bark somewhat rough, greenish. Leaves broadly ovate or orbicular, abruptly very shortly acuminate, the acumen less than one-half inch long, 8 to 10 inches long, glabrous above, pubescent on the nerves beneath, the nerves prominent, about ten pairs.

It has already been stated that no rubber-producing trees have been found. That is to say a great many species of trees have been discovered which are known to produce a milk or latex, and while none so far studied contained rubber, it is scarcely to be supposed that when material from all has been collected, some at least will not be found to yield a good product.

The extent of territory covered by these two rubber vines is given by map No. 2. While the Panameria is found in Mindoro, Culion, and the other northern islands, the undetermined species was found on Tawi-tawi, Basilan, and Mindanao. The extent of territory covered in these various places was estimated after extensive personal investigations when all available data had been secured from natives, merchants, etc. In the northern islands, excepting Mindoro, the area covered is given as reported by those who found specimens of the vine. There is every reason to believe, however, that careful investigations would show much larger areas. In Mindoro the natives in all the coast towns knew the rubber vine "Dactang ajas" (medicine for snakes) and many of them brought us samples from the neighboring forest. They all reported large numbers of vines in the interior of the island, and the three expeditions made there from the north, west, and south sides confirmed their statements.

In Mindanao the two areas given between Dinas and Tucuran, in the mountains near the south coast, are the only ones known so far, and even these were only found by accident. The natives knew nothing of rubber, but they had a vine which contained a milky substance, good either as a medicine or for making the heads of their drum sticks. On securing a piece of this peculiar substance from the latter it was found to be a good sample of rubber. Further explorations to the west and east will probably prove that this vine covers about the same area as that occupied by the gutta-percha trees.

In Basilan and Tawi-tawi the vine grows abundantly and to a large size. In the latter island the Moros understand its commercial value, and those engaged in collecting gutta-percha gather rubber at the same time, sometimes mixing the rubber and gutta milk.

THE GRADE OF RUBBER PRODUCED.

Rubber milk or latex is contained in the bark of certain vines and trees in exactly the same manner as is gutta-percha (see fig. 48). When made to flow the same phenomenon of coagulation apparently sets in quickly or slowly, according to the species of the plant. In many species of trees the coagulation is very slow and the flow of milk more abundant than with gutta-percha trees. As a result the natives have evolved the method of tapping the trees similar to that shown in fig. 49. The milk thus secured is coagulated in a manner similar to that employed with gutta-percha.

Another method which seems to give the best results, and which is employed in the preparation of Para rubber, consists in subjecting thin layers of the milk, placed on the broad end of a paddle, to the coagulating action of smoke produced by burning certain husks which are similar to those of cocoanuts. The smoke contains creosote and acid fumes, which quickly destroy all fungus growths and bacteria which might tend to cause decomposition of the rubber, while the heat removes the greater part of the moisture at the same time.

A chemical analysis of many grades of rubber coming from different species of trees and vines shows them, with the exception of variable amounts of water and dirt, to be composed almost entirely of rubber, with a small per cent of resins. The rubber in all has apparently the same chemical composition, an ultimate analysis giving the formula $C_{10}H_{16}$. Chemically, then, there appears to be only one rubber, while physically certain differences are to be found between samples from different species. Whether the superiority of Para rubber is due, therefore, to the excellency of the rubber itself or to the above-mentioned method of coagulation has not yet been determined. However, it is a fact that Para rubber from the tree species *Hevea trasiliensis* Mull. Arg. is recognized as the standard for grading rubber commercially.

It will be noted that the method before mentioned is one requiring skill, judgment, and the expenditure of considerable labor. In most rubber countries the native collectors possess none of these requisites and are content to employ the crudest methods. In consequence the rubber obtained is of a low grade, even though the species of tree is of the best.

The Philippine rubber collectors are Samal and Joloano Moros, living in Tawi-tawi and the adjacent coral islands. The method of coagulation used by them was undoubtedly learned from the Moros of north Borneo, who with the Dyaks collect much of the rubber in that island. It consists in first pulling the vine down to the ground so as to be better able to tap it along its entire length. The milk is caught in cocoanut shells or leaves, and coagulated by pouring into sea water. The coagulation is almost instantaneous, and when properly manipulated a large amount of water can be mechanically inclosed inside the large balls along with plenty of chopped-up bark. The resulting rubber, of which I secured many samples, is white, tough, and very elastic so long as it is kept in sea water. On exposure to the air it blackens, and decomposition slowly sets in.

The chemical analysis of a sample of this rubber, after much of the dirt and water had been removed, resulted as follows:

	Per cent.
Dirt	3.76
Rubber	81.57
Resins	3.16
Water	11.51

Judging from this analysis the rubber in Singapore would be rated as Borneo No. 1, which sells for $125 Mexican per picul of 133 pounds.

The vines generally die after being pulled down and tapped, probably because of their inability to again reach light and sunshine.

The rubber from the Mindoro species has never apparently been gathered in any quantities even by the natives. When the bark is cut the milk flows readily and coagulates quickly. In appearance it is very similar to the Tawi-tawi rubber. As yet no chemical analysis has been made. In order to get a valuation of it a sample was submitted to the Goodyear Rubber Company, of Akron, Ohio, who placed it at about 60 cents per pound, after allowance is made for the percentage of water. Larger samples of both kinds of rubber are now being prepared in the laboratory in order that they may be submitted simultaneously to rubber experts.

THE PHILIPPINES AS A RUBBER-PRODUCING COUNTRY.

(*a*) *Thorough utilization of the natural supply.*—Judging from the way the natives of Tawi-tawi gathered rubber when left to their own devices I was convinced that they wasted as large amounts of the milk as they did when they collected gutta-percha—that is, ten to forty times more than they took away. It is evident then that under present conditions the history of the rubber vines will be the same as that of the gutta-percha trees, only on a smaller scale. It is useless, in my opinion, to think of tapping them only, for an inspection of their tortuous windings up and around the high forest trees (see fig. 50) will show the impossibility of ever collecting the milk, no matter how carefully the tapping were done.

To get the full value from the vine the rubber must be extracted from the entire bark. Experiments along that line are now in progress in the laboratory and so far promise well. If the entire vine be cut into pieces and dried, the bark easily separates from the wood and forms 44 per cent of the entire plant. By grinding the bark in any ordinary mill the rubber separates in the form of small balls while the bark passes off as powder. The dried bark contains 9 to 10 per cent by weight of pure rubber (see fig. 48), which shows this substance to be about 4 per cent of the entire vine. The other conditions and details will be investigated by the laboratory with a view of determining methods which will make possible the investment of American capital.

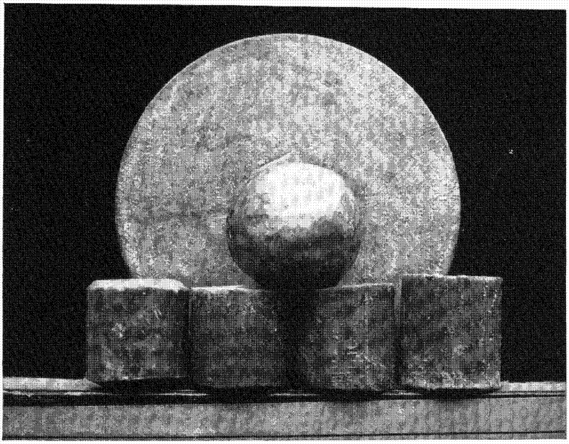
It is true that the method of collecting rubber given above kills the vine. The answer to this objection is found in the fact that when the vine has been cut-off the roots stool again quickly. On a hillside in Mindoro, where the natives had burned the forest for the purpose of planting rice, scores of stools from rubber vines were counted while the fire was yet smoldering in some of the old stumps and roots of the large trees.

(*b*) *Through introduction of foreign species of rubber trees.*—It was stated previously that no rubber trees were found in the islands. Exception should be made to the beautiful specimens of the india-rubber tree (*Ficus elastica* Linn.) which were introduced throughout the archipelago by the Spanish years ago as ornamental shade trees rather than as rubber producers. They are excellent examples of the way foreign species of rubber trees will grow here, and may also serve the still better purpose, that of furnishing seeds and slips to start rubber plantations. Many plantations of this tree have been begun in Java, the reasons for the selection of this species being: (1) The seeds are numerous and the plants will grow. (2) The method of starting new plants by marcottage (see fig. 38) succeeds very well and the plants have vigorous growth (see fig. 51). (3) The method of coagulation best suited for this milk is the simplest of all. It consists of making many small cuts in the bark of the trunk and allowing the outflowing milk to coagulate in strings. When dry and hard they are pulled off and pressed into a compact mass (see mass of rubber on the left, fig. 52) for shipment. The work can be done by even ignorant workmen and with no damage to the tree.

In the Malay States a great many plantations are now being started with Para rubber trees, the seeds of which are secured from the various government botanical gardens as well as from private plantations (see fig. 54). One of this species of trees is now growing in Manila and apparently the climate is suitable. The bureau of agriculture has distributed many Ceara rubber seeds during the past year and the growth of the seedlings is marvelous.

In general the climatic conditions of most of the islands seem very favorable for the rubber industry. Mindoro and the southern islands especially are advantageous on account of the abundant rainfall distributed throughout the year with no long season of drought.

What pests and parasites the rubber trees would be troubled with can only be conjectured by reference to the experiences of Java, etc. Doctor Zimmerman extended his work on parasites to include rubber trees and has found one or two species of insects that may cause damage. Cattle and goats must also be guarded against.



SAMPLES OF PURE GUTTA PREPARED IN THE LABORATORY FOR EXPERIMENTAL PURPOSES.

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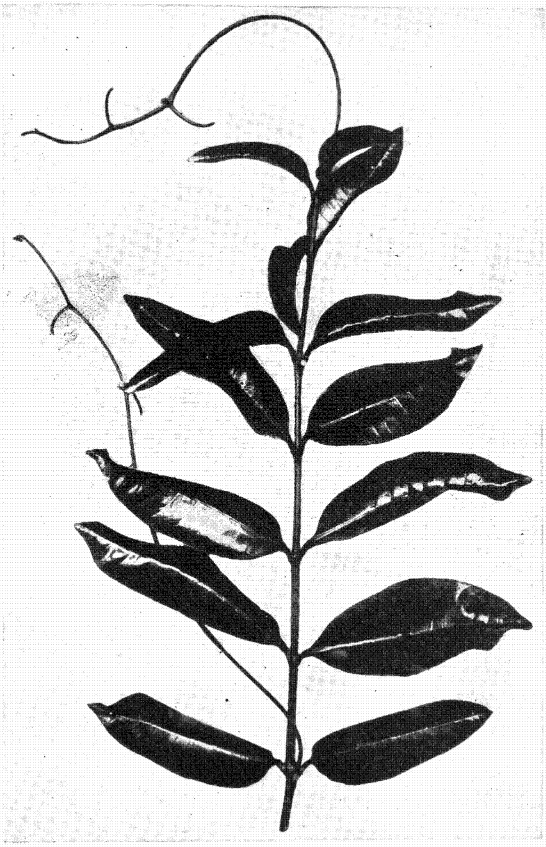

RUBBER VINE (WILLUGHBEIA FIRMA BLUME). THIS SPECIES SUPPLIES MOST OF THE RUBBER PRODUCED IN BORNEO.

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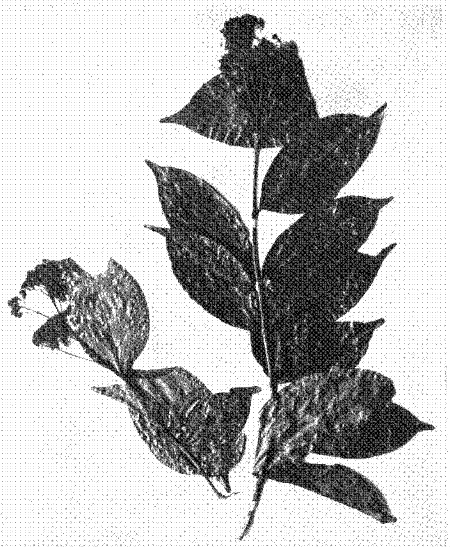

RUBBER VINE (PARAMERIA PHILIPPINENSIS RADLK.), GROWING IN GREAT ABUNDANCE ON ISLANDS OF MINDORO AND CULION.

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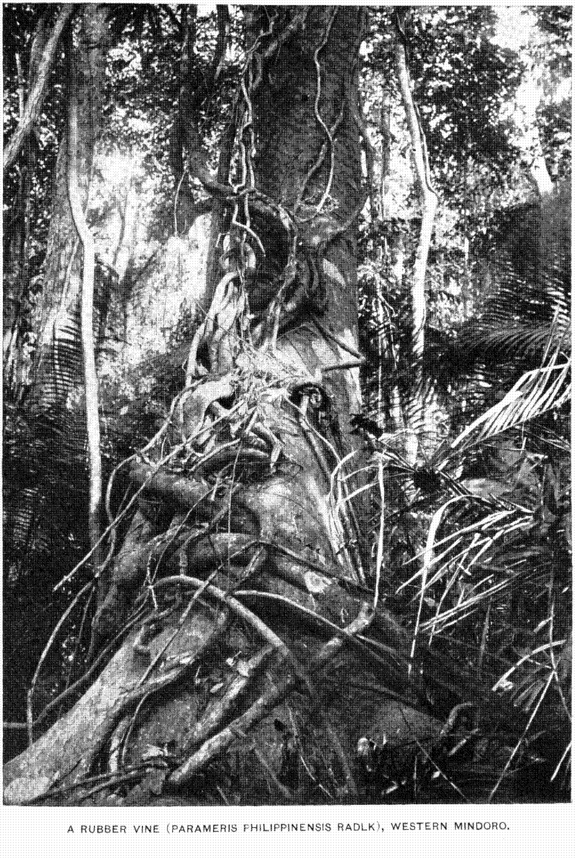

A RUBBER VINE (PARAMERIS PHILIPPINENSIS RADLK), WESTERN MINDORO.

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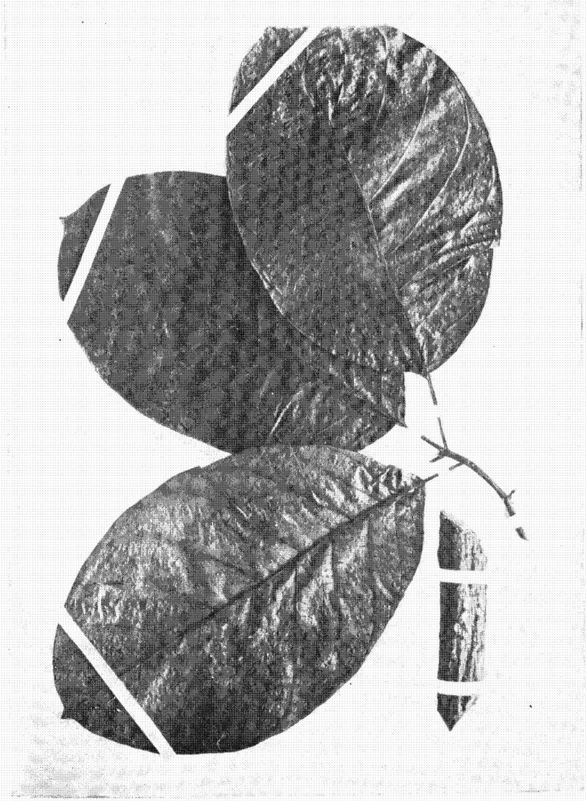

RUBBER VINE FOUND IN TAWI TAWI, BASILAN, AND MINDANAO. SPECIES UNDETERMINED.

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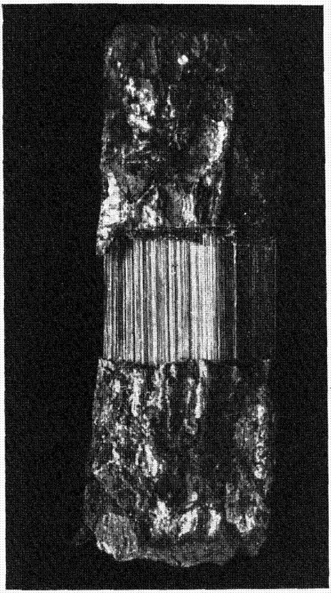
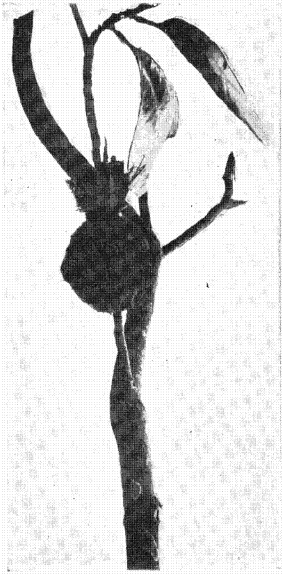


PIECE OF DRY BARK FROM RUBBER VINE, SHOWING THE IMMENSE NUMBER OF RUBBER FIBERS IN THE INNER BARK.



SHOWING METHOD OF PROPAGATING *GUTTA-PERCHA TREES* BY MEANS OF MARCOTTAGE, BUITENZORG, JAVA.

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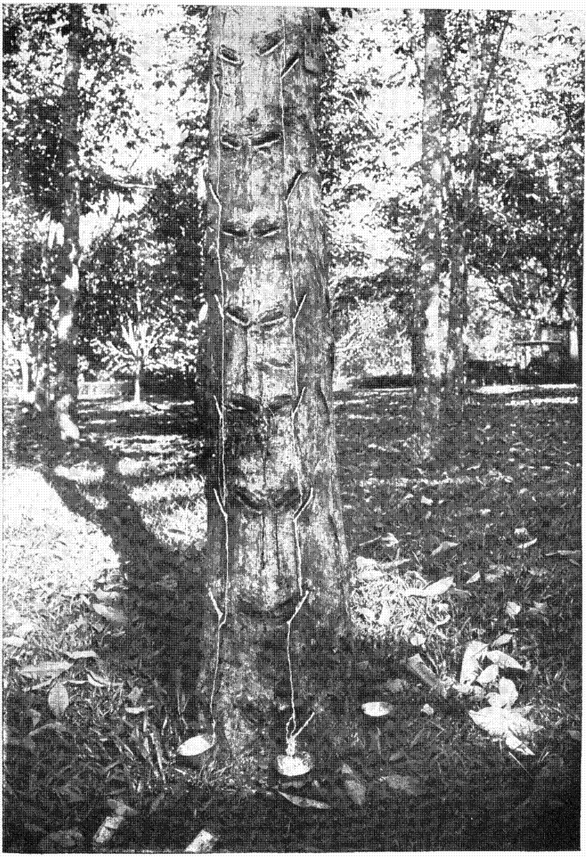

METHOD OF TAPPING A PARA RUBBER TREE THIRD DAY AFTER TAPPING, EXPERIMENTAL GARDEN, BUITENZORG, JAVA.

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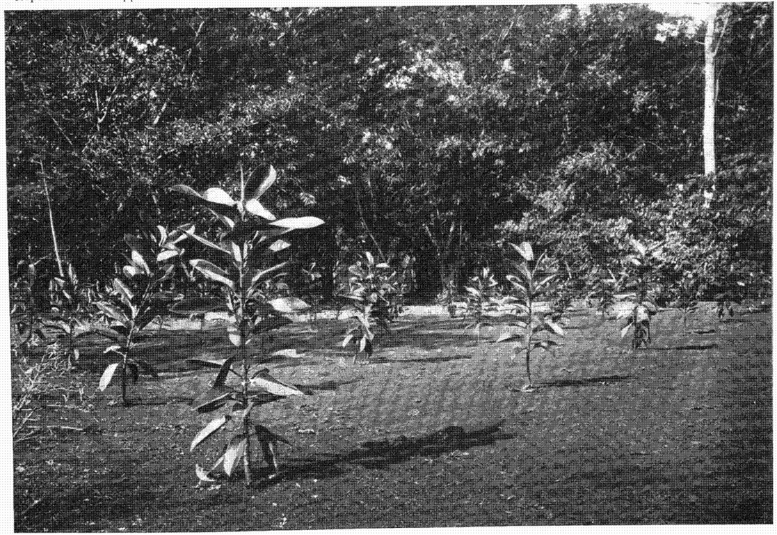
RUBBER VINE GROWING IN THE FOREST, WESTERN, MINDORO.



PLANTATION OF INDIA RUBBER TREES (FICUS ELASTICA), BUITENZORG, JAVA.

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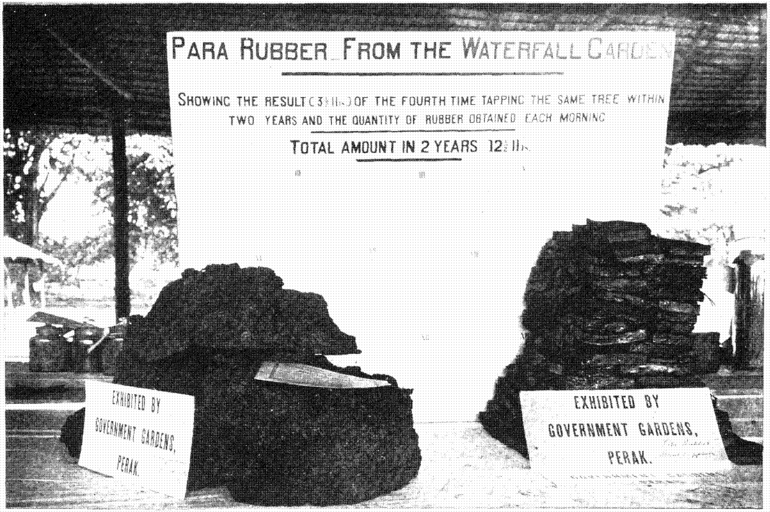
PARA RUBBER FROM THE WATERFALL GARDEN
SHOWING THE RESULT (3½ lbs.) OF THE FOURTH TIME TAPPING THE SAME TREE WITHIN TWO YEARS AND THE QUANTITY OF RUBBER OBTAINED EACH MORNING
TOTAL AMOUNT IN 2 YEARS 12½ lbs.
EXHIBITED BY GOVERNMENT GARDENS, PERAK.
EXHIBITED BY GOVERNMENT GARDENS, PERAK.

EXHIBIT OF PARA RUBBER, SHOWING YIELD OF TREES AND METHODS OF PREPARING FOR MARKET, PERAK PROVINCE, FEDERATED MALAY STATES.

LARGE INDIA RUBBER TREE (FICUS ELASTICA L.), BUITENZORG, JAVA.

PLANTATION OF PARA RUBBER TREES, PRODUCING SEED, BOTANICAL GARDEN, SINGAPORE.

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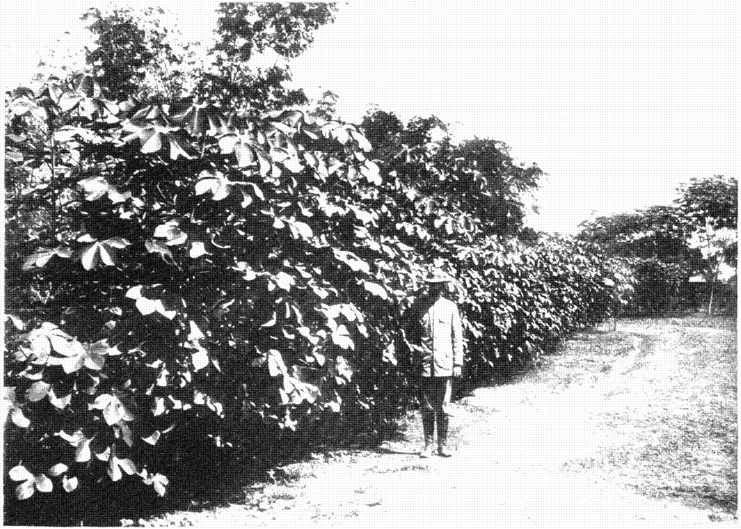


CEARA RUBBER PLANTS, EXPERIMENT STATION, MALATE

It is needless to dwell on the commercial side of rubber plantations. They are now flourishing in all tropical countries and as an agricultural investment are highly considered. However, in all new countries a certain amount of experimental work must be done before large capital can be safely invested. In India, Burmah, the Malay States, and Java this has been accomplished by the respective governments. As soon as methods were perfected and seed supplies provided, private capital began operations at once. From the number of inquiries already made about rubber planting in these islands, it would look as if some movements in this direction are contemplated here, investors only waiting for the Government to pave the way. By profiting from the extensive experience of our neighboring countries the experimental era should be short and inexpensive, as a great deal of the pioneer work has been done.

Exhibit C.

REPORT OF DR. RICHARD P. STRONG, DIRECTOR OF THE BIOLOGICAL LABORATORY, COVERING THE PERIOD FROM AUGUST 31, 1902, TO AUGUST 31, 1903.

CLINICAL LABORATORY WORK FOR GOVERNMENT INSTITUTIONS AND FOR PRIVATE PHYSICIANS.

During the past year a greatly increased demand has been made upon the laboratory for clinical work, the total number of examinations performed from August 31, 1902, being 6,535, as against 3,816 for the previous year. Table No. VI will give an idea of the number and character of the specimens submitted for diagnosis. It is interesting to consider for a moment the tables showing the results of these analyses from a statistical point of view. Thus from No. VII it may be seen that in the study of the sputa of patients suspected to be tuberculous, 244 of whom were natives and 72 Caucasians, tubercle bacilli were found more than four times as frequently in the former as in the latter. The great number of examinations of sputa for natives suspected to be phthisical in excess of that performed for white people also suggests the more extensive prevalence of pulmonary tuberculosis among the former. From the same table it is evident that at least 1.2 per cent of the inmates of Bilibid Prison are suffering with phthisis, tubercle bacilli having been isolated from 31 cases. On the other hand, Table No. VIII might lead us to conclude that the white race is more susceptible than the native to typhoid and malarial fevers; however, comparatively few cases of either of these diseases have occurred during the past year either in government institutions or indeed in the city as a whole.

Table No. VI shows that, in spite of the continuous effort to diminish the number of cases affected with gonorrhea, 1,581 bacteriological examinations of prostitutes have shown infection with the disease during the year, this number being 37 per cent of the total number of examinations (4,269). However, if we consider the statistics of cases encountered during the past three months, we find that less than 33 per cent of those examined are diseased. During the previous year, out of 1,142 prostitutes, 447, or about 39 per cent of the total number, were found to be infected. These figures demonstrate with striking force how important and necessary it is that we continue our efforts to restrict, or if possible to suppress, this great scourge in the city of Manila.

Table No. IX gives one some idea of the intestinal parasitic diseases prevailing in the islands and of the proportion of amebic dysentery to other intestinal maladies, the former comprising at least one-sixth of the total number of such enteric diseases. These figures, however, may in one respect be somewhat misleading, as many of the specimens of feces from cases of intestinal disorders sent to the laboratory for examination have been unfavorable for the observation of amebæ, owing to the fact that the specimens were either too old or mixed with substances deleterious to sarkodina. From these facts, therefore, and particularly from clinical studies previously made, it seems more than likely that amebic dysentery constitutes considerably over one-sixth of all intestinal dsturbances in and near this city. Uncinariasis apparently ranks next to dysentery in prevalence.

TABLE No. VI.—*Clinical laboratory examinations.*

	Civil Hospital.			Bilipid Prison.			San Lazaro Hospital.		
	P.	N.	T.	P.	N.	T.	P.	N.	T.
Sputum	20	76	96	31	169	200			
Urine			167						
Malaria, blood for	17	169	186	0	45	45			
Blood counts			246			2			
Serum reactions	5	63	68	0	1	1			
Gonococci	53	17	50				729	1,006	1,735
Feces			541			177			
Total			1,354			425			1,735

	Sampaloc district.			Private physicians.			Totals.		
	P.	N.	T.	P.	N.	T.	P.	N.	T.
Sputum				5	15	20	56	260	316
Urine						68			235
Malaria, blood for				4	7	11	21	221	242
Blood counts						11			259
Serum reactions				0	3	3	5	67	72
Gonococci	816	1,665	2,481	3	0	3	1,581	2,688	4,269
Feces						31			749
Pseudo farcy									5
Glanders									3
Surra							24	115	139
Necropsies									200
Miscellaneous									46
Total			2,481			147			6,535

P = examinations showing organisms (positive). N = examinations showing absence of organisms (negative). T = total.

TABLE No. VII.—*Microscopic examination of urine and sputum.*

	Native.	Foreign.	Total.
Urine:			
Civil hospital	21	146	167
Private physicians	40	28	68
Total	61	174	235

	Native.		Foreign.		Total.		Grand total.
	P.	N.	P.	N.	P.	N.	
Sputum for tuberculosis:							
Civil hospital	15	31	5	45	20	76	96
Bilibid prison	27	153	4	16	31	169	200
Private physicians	4	14	1	1	5	15	20
Total	46	198	10	62	56	260	316

TABLE No. VIII.—*Blood examinations.*

	Civil Hospital.						Bilibid Prison.					
	Native.			Foreign.			Native.			Foreign.		
	P.	N.	T.	P.	N.	T.	P.	N.	T.	P.	N.	T.
Hemoglobin						2			9			
Erythrocytes, count			9			55			1			
Erythrocytes, count difference			1			2						
Leucocytes, count			26			150			1			
Leucocytes, count difference			1			2						
Malaria			35			151			43			2
Tertian	2	33		5	146							
Estivo-autumnal	1	34		9	142							
Quartan		35			151							
Serum reactions:												
Typhoid fever		8	8	4	51	55		1	1			
Malta fever						3						
Dysentery				1	1	2						
Trypanosomiasis												
Total			80			420			55			2

	Private physicians.						Total.						Total.
	Native.			Foreign.			Native.			Foreign.			
	P.	N.	T.	P.	N.	T.	P.	N.	T.	P.	N.	T.	
Hemoglobin									9			2	11
Erythrocytes, count			1			1			11			56	67
Erythrocytes, count difference						1			1			3	4
Leucocytes, count			1			4			28			154	182
Leucocytes, count difference						3			1			5	6
Malaria			2			9			80			162	242
Tertian				4			2			9			
Estivo-autumnal													
Quartan													
Serum reactions:													
Typhoid fever		1	1		2	2		10	10	4	43	57	67
Malta fever												3	3
Dysentery										1	1	2	2
Trypanosomiasis													
Total			5			20			140			444	584

TABLE No. IX.—*Examination of feces.*

[(N.) Native. (F.) Foreign. Total feces examinations made: Native, 212; foreign, 537; total, 749.]

Parasites.	Civil Hospital.		Bilibid Prison.		Private physicians.		Total.		Per cent positive.	
	N.	F.	N.	F.	N.	F.	N.	F.	N.	F.
Amœbæ	2	70	51	3	1	5	54	78	25	14
Monads	4	61	13			10	17	71	8	13
Strongyloides intestinalis		1	1				1	1	.4	.2
Trich. dispar	6	23	5	1		3	11	27	.5	.5
Uncinaria	4	22	13			2	17	24	.8	.4
Ascaris lumb	4	3	4		1		9	3	.4	.5
Tænia										
Balantidium coli		2						2		.3
Megastoma enter		1						1		.2
Trichomonas and ascaris lumb	1						1		.4	
Trichomonas and uncinaria	1	2		3			1	5	.4	.9
Amœbæ and monads	2	10		3			2	13	.9	.2
Amœbæ, trichomonas, and uncinaria	2	2					2	2	.9	.3
Small amœbæ	1	14	2	2		1	3	17	.1	.3
Uncinaria and ascaris lumb		2		2		1		5		.9
Amœbæ, monads, and uncinaria		2	1	1			1	3	.4	.5
Trichomonas, monads, and uncinaria		2						2		.3
Amœbæ and uncinaria		1		3				4		.7
Monads and uncinaria		4				1		5		.9
Amœbæ, monads, uncinaria, and trichocephalus dispar		3		1				4		.7
Small and large amœbæ	1	2		1		1	1	4	.4	.7

Figures given are those found positive.

TABLE No. X.—*Necropsies.*

	Native.
Plague:	
Septicæmic	12
Bubonic	71
Pulmonic	10
Cholera	63
Beriberi	2
Smallpox	1
Leprosy	2
Malta fever	1
Dysentery	5
Miscellaneous	39
Total	206

OTHER ROUTINE WORK.

In addition to the clinical laboratory work there have been performed for the board of health 206 necropsies for the diagnosis of contagious and infectious diseases, a number of examinations for the diagnosis of animal diseases, such as surra, glanders, pseudofarcy, hemorrhagic septicæmia, etc., and analyses of potable and mineral waters (many of which have been condemned as a result), as well as a considerable number of miscellaneous examinations.

The examination of rats for infection with *Bacillus pestis bubonicæ* has been continued by the laboratory during the year. Out of 1,623 rats examined, one-sixteenth of 1 per cent were found to be infected with this organism, as compared with 0.34 per per cent during the previous year. The value and importance of these examinations were explained in the report for the year 1902. During the past year the laboratory has encountered 98 fatal cases of plague, 71 of which were of the bubonic type, 12 of the septicæmic, and 10 of the pulmonic. About one-third of these occurred in women, the ages of the victims varying from 2 to 72 years. There have been 75 autopsies performed upon cases of Asiatic cholera, one-third of which were upon females. It has not been thought advisable to give here the detailed statistics of the anatomical lesions found in the plague and cholera necropsies.

BACTERIOLOGIC EXAMINATIONS OF WATER.

During the year, as already stated, numerous bacteriologic analyses of drinking water have been performed. In a large number of wells examined 4 showed the presence of *Spirillum choleræ asiaticæ,* and as a result of these examinations the wells in question were promptly closed by the board of health. In several other cases well waters have been condemned as unfit for drinking purposes, either on acconnt of the presence of excessive numbers of bacteria or because they contained organisms of the colon typhoid group.

The question of the quality of the drinking water used in the city of Manila has always been an important one. In my report of the previous year I called attention to the fact that this water frequently showed the presence of varieties of Sarkodina and Mastigophora, demonstrating how unsafe it was for drinking purposes until it had been thoroughly boiled or filtered. At certain periods of the year this water, even from a bacteriological standpoint, is far from what should be desired. Probably the majority of the white population of Manila avoid using it unless it has been boiled, filtered or distilled. The practice of many, as is well known, is to obtain their daily supply of water from some distilling plant, or to boil the city water, afterwards placing it in receptacles on ice. As it is often a difficult matter to keep these receptacles sterile, on account of the carelessness or ignorance of those (usually servants) who attend to them, the water in one way or another becomes infected in a great many cases, so that at the end of from twelve to twenty-four hours it is no longer fit to drink, either from the fact that it contains an excessive number of bacteria or because amœbæ are present in such large numbers as to be visible simply upon microscopic examination. With a view to furnishing the public with some safe means of preparing drinking water, and in particular for those who are obliged to travel in the provinces where at times it is difficult to obtain pure water, it was thought advisable to undertake experiments in order to find some simple and practical method of sterilizing water with chemical substances.

The following report of Dr. W. B. Wherry, pathologist in this laboratory, seems to demonstrate that benzoyl-acetyl peroxide is valuable in the sterilization of drinking water against bacteria under certain conditions. This report is herewith submitted.

THE USE OF ACETOZONE (BENZOYL-ACETYL PEROXIDE) IN THE STERILIZATION OF WATER FOR DRINKING PURPOSES.

(Dr. W. B. Wherry, pathologist, biological laboratory.)

The following experiments were performed to determine a safe and yet sufficiently small amount of acetozone necessary to render Manila tap water fit for drinking purposes:

The method employed was that commonly used, viz, adding a known quantity of the germicide to a definite quantity of water, allowing it to act for a definite period, plating a constant quantity of the mixture, and counting the colonies. Control plates of tap water were made in each case.

In certain instances where growth resulted the general character of the organisms, with reference to whether they were spore forming or not, was determined after forty-eight hours by microscopical examination. A 1:1,000 solution of acetozone, prepared every morning, was used each day. Control counts showed the presence of between 100 and 300 bacteria per cubic centimeter.

As shown by Table XI, acetozone added to tap water in the strength of 1:10,000, 1:30,000 and 1:60,000, destroyed the majority of the organisms present. Those surviving its action were chiefly molds, spore, forming organisms of the bacillus subtilis type, and a few cocci. Its action was more marked in five minutes than in one.

TABLE XI.

Character of colonies.	Amount of acetozone present.	Amount of water plated.	Time of action in minutes.	Number of colonies present in—	
				24 hours.	48 hours.
		c. c.			
Spore-bearing bacilli and molds	1:10,000	1	1	14	17
	1:10,000	1	3	4	10
	1:10,000	1	5	6	9
Spore-bearing bacilli and a few cocci	1:30,600	1	1	4	5
	1:30,000	1	3	6	9
	1:30,000	1	5	1	4
Spore-bearing bacilli and molds	1:60,000	1	1	Many.	(a)
	1:60,000	1	3	4	8
	1:60,000	1	5	6	9
Do	1:10,000	1	1	2	2
	1:10,000	1	3	5	15
	1:10,000	1	5	1	4
Spore-bearing bacilli	1:30,000	1	1	3	(a)
	1:30,000	1	3	8	8
	1:30,000	1	10	4	8
Do	1:60,000	1	1	7	(a)
	1:60,000	1	3	4	(a)
	1:60,000	1	5	1	1
	1:60,000	1	30	2	2

a Overgrown.

In order to determine more definitely its action on such nonspored organisms as *B. typhosus*, *B. dysenteriæ*, and *Sp. choleræ asiaticæ*, which have about the same powers of resistance to destructive agencies, a further test was made.

Three hundred cubic centimeters of tap water was placed in each of two clean flasks and sterilized in the autoclave at 135° C. When cool 1 cubic centimeter of a 20-hour old culture of *B. typhosus* in bouillon was added to each flask in the proportion of 1:30,000 and 1:60,000, respectively. One cubic centimeter of this emulsion was plated in agar melted and cooled to 40° to 50° C. at intervals of five, ten, and thirty minutes.

TABLE XII.—*Tap water (autoclaved) 300 c. c. to 1 c. c. 24-hour B. typhosus in bouillon.*

Amount of water plated.	Amount of acetozone present.	Time of action in minutes.	Number of colonies in—	
			24 hours.	48 hours.
c. c.				
1	1:30,000	5	....	....
1	1:30,000	10	....	....
1	1:60,000	5	1 (div)	1 (do.)
1	1:60,000	10	....	....
1	1:60,000	30	....	....
1	....	....	Innumerable.	

Table XII shows that 1/300 c. c. of the emulsion contained innumerable typhoid bacilli and that the acetozone produced complete sterilization in five minutes.

A 1:60000 solution of acetozone is tasteless, and it is recommended that it be employed, in a fresh condition, at about this strength (16 c. c. of a 1:1000 solution per liter of water) and that it be permitted to stand fifteen minutes to half an hour before use.

This work is confirmatory of that performed by Dr. P. G. Novy, of the University of Michigan, on the value of acetozone as a disinfectant.

Dr. W. E. Musgrave is now undertaking experiments to determine the strength of a solution of acetozone necessary to kill the variety of amœbæ cultivated from the city water supply.

The following experiments of Dr. P. G. Wooley of this laboratory relating to the action of citric acid on the cholera spirilla found in drinking water are of interest:

THE ACTION OF CITRIC ACID ON THE SPIRILLUM OF ASIATIC CHOLERA.

(Dr. P. G. Wooley.)

In the following communication are reported some experiments made with pure cultures of the spirillum of Asiatic cholera isolated from the intestines of persons dead of the disease. This work was stimulated by the fact that the growth of the organism of Asiatic cholera is inhibited by the presence of acid in the medium upon which the organism is planted, and by the desire to find a safe and palatable substance which can be added to water to render it safe for drinking purposes, at least so far as cholera is concerned.

For the first series of experiments a 2 per cent solution of pure citric acid was used. This was added to tubes of 2 per cent peptone in the proportion of 1, 2, 3, 4, 5, and 6 c. c. to each 10 c. c. of peptone solution. To each of these mixtures was added a loopful of a twenty-four hour old culture of the spirilla of Asiatic cholera, and from each of these agar plates were made at the end of ten and twenty minutes.

I.

	Peptone.	2 per cent citric acid.	Number minutes.	Number colonies.
	c. c.	*c. c.*		
Tube I	10	1	10	3
			20	....
Tube II	10	2	10	3
			20	....
Tube III	10	3	10	....
			20	....
Tube IV	10	4	10	....
			20	Many.
Tube V	10	5	10	....
			20	....
Tube VI	10	6	10	....
			20	....
Control	10	....	10	Countless.
			20	Countless.

After twenty-four hours no motile organisms were found in any except the control, which was the only one that produced the "cholera red" reaction.

A second series of experiments was made with the same solution, but with greater precautions, and the results were as follows:

II.

	Peptone.	2 per cent citric acid.	Number minutes.	Number colonies.
	c. c.	*c. c.*		
Tube I	10	2	10	....
			20	....
Tube II	10	4	10	....
			20	....
Tube III	10	6	10	....
			20	....
Tube IV	10	8	10	....
			20	....
Tube V	10	10	10	....
			20	....
Control	(*a*)	....	10	Countless.
			20	Countless.

a Plain peptone solution.

At the end of twenty-hours the fluid in the tubes was clear and no motile organisms were seen. The contents of the control were cloudy and gave the "cholera red" reaction.

A third series was as follows:

III.

	2 per cent peptone.	2 per cent citric acid.	Number minutes.	Number colonies.
	c. c.	*c. c.*		
Tube I	10	2	10	1
			20	....
Tube II	10	4	10	1
			20	....
Tube III	10	6	10	....
			20	....
Tube IV	10	8	10	2
			20	....
Tube V	10	10	10	....
			20	....
Control	(a)	....	10	Countless.
			20	Countless.

[a] Plain peptone solution.

The colonies from Tube I were those of a coccus, from Tube II of a large bacillus, and from Tube IV of a large spore-bearing bacillus. The fluid in all the tubes is clear at the end of twenty-four hours, while the control was cloudy and gave the "cholera red" reaction.

A fourth series was next undertaken to discover the efficacy of lemon juice as a disinfectant. The amount of citric acid in the foregoing experiments was so small that it seemed natural to suppose that lemon juice would act satisfactorily if employed in the proper amount and yet in a solution sufficiently dilute to be palatable and harmless.

With these points in view, the following tests were made with the pure juice expressed from large fresh lemons:

	2 per cent peptone.	Lemon juice.	Number minutes.	Number colonies.
	c. c.	*c. c.*		
Tube I	10	$\frac{1}{5}$	10	3
Tube II	10	$\frac{1}{2}$	10	3
Tube III	10	1	10	....
Tube IV	10	2	10	....
Tube V	10	3	10	....
Control	(a)	....	....	Countless.

[a] Plain 2 per cent peptone solution.

Indol reaction in the control was positive. Tubes IV and V remained clear until the end of sixty hours, when molds grew plentifully in them.

A final experiment was made to determine the value of the common lime sirup sold at drug stores under the name of "Jarabe de Limon:"

	2 per cent peptone.	Lime sirup.	Number minutes.	Number colonies.
	c. c.	*c. c.*		
Tube I	10	$\frac{1}{5}$	10	Countless.
Tube II	10	$\frac{1}{2}$	10	Countless.
Tube III	10	1	10	Countless.
Tube IV	10	2	10	300
Tube V	10	3	10	2
Control	(a)	....	10	Countless.

[a] Plain 2 per cent peptone solution.

Control gave the "cholera red" reaction at the end of twenty-four hours. All of the tubes except No. V were cloudy and showed motile spirilla.

The value of such experiments is, of course, not great, since it is not safe to trust to such chemical means of rendering bad water fit to drink, but the results are interesting and of some possible value, especially in cases of emergency. The conclusion that we may draw from this is that water rendered so acid that the degree of acidity is equal to from one-half per cent to 1 per cent of citric acid is fairly safe so far as cholera is concerned.

We find from an analysis made in the laboratory that a large fine lemon contains 6.86 grams of crystallized citric acid per 100 c. c. The lemon used contained 40 c. c. of juice, which is equivalent to 2.744 grams of citric acid. At this rate half the juice of a lemon, the amount usually employed for a glass of lemonade, would be equivalent to 1.37 grams of citric acid.

RESEARCH WORK.

The time taken up by routine work, laboratory examinations for the diagnosis of human and animal diseases, analyses of waters, etc., has left but comparatively little time for research. However, special studies have been pursued by Dr. W. E. Musgrave and Mr. M. Clegg on surra, by Drs. P. G. Wooley and J. W. Jobling (the latter of the serum laboratory) on hemorrhagic septicæmia of animals, by Dr. W. B. Wherry on hand infection due to organisms resembling the Koch-Weeks bacillus, by Mr. Charles S. Banks on the insects of cacao, and by myself on protective inoculation against Asiatic cholera. These reports are appended.

On January 31, 1902, I was directed by the Civil Commission to proceed to Europe at my own expense for the purpose of making investigations into recent discoveries in biological science. In addition to the studies which I pursued in Germany, I visited the London School of Tropical Medicine, the German School of Tropical Medicine at Hamburg, the Pasteur Institute at Paris, and the Government civil hospitals at Port Said and at Colombo, Ceylon. Much valuable information was gained from these visits, and while engaged in them I paid particular attention to whatever advancement had been made in laboratory methods, technique, and apparatus, and by conversation and consultation with various men of science endeavored to obtain information with regard to advanced methods of dealing with future problems in tropical diseases.

At the Pasteur Institute in Paris, through the kindness of Professors Metchnikoff and Laveran, the work done at this institute on nagana, a disease very closely allied to if not identical to surra, was carefully gone over with me, Professor Laveran reviewing his specimens and studies upon this subject and offering suggestions for future lines of investigations.

At the tropical schools of medicine at London and Hamburg opportunities were presented for the observation of parasitic and other diseases, which hitherto have occurred more commonly in Africa, but which may from time to time find their way to the Philippine Islands.

During several days spent in observation at the London School of Tropical Medicine, I was invited by Sir Patrick Manson, K. C. M. G., F. R. S., to read a paper before the Epidemilogical Society in connection with the question of the Panama Canal and its relation to the introduction of yellow fever into Asia. The object of this meeting, opened by Sir Patrick Manson, was to call attention to the work of the late Dr. Walter Reed and of his associates in relation to yellow fever, and to urge upon the Congress of the United States the importance ot placing a medical man on the Panama Canal Commission for the purpose of bringing about proper sanitary conditions along the shores of the canal, and of ridding this region of the disease, as has already been done in Habana through the efforts of Wood and Gorgas, acting upon the observations of Walter Reed. As the subject is one of so great importance to the Philippine Islands, it has been thought advisable to call attention to it in this report in the article appended with the other special reports from the biological laboratory.

In Berlin, having obtained admission to the Königl. Institut für Infektionskrankheiten (Herr Geh. Med. Rath, Prof. Dr. R. Koch, director), through the courtesy of Profs. William H. Welch and William Osler, of Johns Hopkins University, and Profs. C. A. Ewald and A. Wassermann, of the University of Berlin, I took up my special work in immunity in the department of Professor Wassermann, and as an outcome of some of these studies the report on the production of a cholera vaccine is submitted. In addition to these bacteriological researches, daily work was performed in the pathological laboratory of either the Charité or the Augusta Hospital.

I arrived in Manila on July 13, and resumed my duties as director of the biological laboratory.

The special reports from the biological laboratory are appended.

REPORT ON TRYPANOSOMA AND TRYPANOSOMIASIS, WITH SPECIAL REFERENCE TO SURRA, IN THE PHILIPPINE ISLANDS, BY W. E. MUSGRAVE, M. D., AND MOSES T. CLEGG.

INTRODUCTION.

Before entering upon a discussion of the text of this report a few remarks regarding the facilities at our disposal appear advisable.

Fig. 3 illustrates a specially constructed insect-proof stable in which all experiments necessitating extraordinary precaution were performed. To obtain satisfactory results such a structure is an absolute necessity. This stable is screened on all sides, the stalls are separated by wire netting, and each is provided with a door of the same kind. On each side there is an additional hall entirely screened and with a single outside door. At one end an insect-proof operating room was built and provided with a protected entrance to the different stalls.

Because of these precautions experiments have been conducted by us with an absolute certainty of results, and owing to a lack of facilities similar to ours many of the conclusions contained in reports relating especially to the transmission of the disease do not appear to have been based upon accurate observations.

Discussions of the transmission of the disease by feeding, based upon observations made without protecting animals from insects, do not, of course, lead to a final settlement of the question; and so with many other conclusions in the voluminous literature relating to this subject.

In reviewing literature we have tried in each instance to give credit to the person to whom due, but in this we may sometimes have failed. The works of Voges, Lingard, Kanthuck, Durham and Bradford, Laveran and Mesnill, Rabinowitch and Kempner, Wasielewski and Senn, and many others have been freely used.

DEFINITION.

The disease is a specific infection of many of the lower animals, and occasionally of man, caused by *Trypanosoma*. It occurs in epidemic form over large areas of tropical countries, and is usually more severe during the rainy season. It is characterized by a period of incubation followed, in most animals, by a remittent, intermittent, or less frequently relapsing fever; by the presence of *Trypanosoma* in the circulating blood, which in some animals are numerous in proportion to the temperature, by progressive anemia and emaciation, by a catarrhal condition of the mucous membranes of the eyes and nose, by roughness of the hair, which in many instances falls out, by subcutaneous edema, more commonly of the posterior extremities, genitals, and belly. In the latter stages paresis of the posterior extremities is very common. The mortality among most animals of economic importance is 100 per cent.

There are found in most animals at post-mortem, in addition to the evidence of severe anemia, certain changes in the spleen, the most constant being enlargement and a peculiar mottling. Taken with other principal lesions, such as lymphatic hyperplasia, peculiar, yellowish, gelatinous, subcutaneous and subserous infiltrations, an enlarged liver, and the accumulation of fluid in the serous cavities, it makes an anatomic picture which is rarely excelled in chronic diseases peculiar to man.

NOMENCLATURE AND CLASSIFICATION.

A list of the various names used to designate trypanosomiasis in different parts of the world has been compiled from literature as follows:

Adjoe.
Andar-tap.
Anémie pernicieuse.
Berbad.
Beschalkrankheit.
Beschalseuche.
Blaschemausschlag.
Bovine surra.
Buffalo surra.
Camel surra.
Canine surra.
Dog surra.
Doaia.
Dourine.
Equine relapsing fever.
Equine surra.
Equine syphilis.
Exantheme coitale.
Fish surra.
Flagellose de equins.
Galtah.
Galtia.
Glossinose.
Horse pox.
Horse surra.
Juckkrankheit.
Khanhog.
Khusk-zaharbad.
La mouche.
Leuma equorum.
Mal de caderas.
Maladie á trypanosome.
Maladie benigne du coit.
Maladie de la tsétsé.
Maladie de Soemedang.
Maladie du coit.
Maladie du prurit.
Maladie vénérienne du cheval.
Marri.
Nagana.
Nikalgaya.
N'gana.
Nygana.
Oae.

Pernicious anemia of horses.
Peste de cadeiras.
Pferdestaupe.
Phenta.
Phenta-ka-darad.
Phera.
Pheta.
Phetra.
Phitgaya.
Photra.
Polynevrite infectieuse du cheval.
Poona.
Purana.
Rat surra.
Relapsing fever of equines.
Sar.
Sara.
Schleichende Fieber.
Sokra.
Sukal.
Surra.
Surra americain.
Surrakrankheit.
Tap.
Tap-dik.
Tape-dik.
Tarai.
Tebersa.
Tibarsa.
Trypanosomose.
Tsétsé fly disease.
Tsétsékrankheit.
Tumby-a.
Tumby-baba.
Wabai-ki-bokhar.
Zaharbad.
Zherbad.
Zuchtlähme.

In this report the term "trypanosomiasis," as suggested by Salmon and Stiles, is used, being in a general sense comparable to the terms "filariasis" and "uncinariasis." Following this classification further, according to the animal infected, we would have trypanosomiasis of man, trypanosomiasis of horses, trypanosomiasis of cattle, etc. Such a nomenclature would apply satisfactorily, whether the infecting parasites are identical or not, and also regardless of the manner and place of infection. For example, the term trypanosomiasis of horses would apply equally well to nagana contracted by the bite of an infected tsétsé-fly in South Africa, and to surra produced by the hypodermic injection of infected trypanosomiatic blood in Manila.

If the parasites causing the diseases known under the old names have been or are shown to be different, there could be no very great necessity for interfering with the better part of the established nomenclature. Surra would then be the trypanosomiasis of horses and of other animals due to an infection with *Tr. evansi;* nagana would be the trypanosomiasis of horses and of other animals due to an infection with *Tr. brucei*, etc.

On the other hand, if these parasites are shown to be the same, or probably more correctly until they are shown to be different, there does not appear any valid reason why any of the names, except that of surra, accepted by Evans, the original discoverer of the pathogenicity of the parasite in animals, should be retained.

Without entering in detail upon a discussion, which will be taken up later in the report, regarding the identity or nonidentity of *Tr. evansii*, *Tr. brucei*, *Tr. rougetii* (equiperdum), and *Tr. elmassianii* (equinum), and hence the identity or nonidentity of surra, nagana, dourine, and mal de caderas, there is considerable difference of opinion, and also considerable inconsistency in some of the writings, especially with reference to the diseases discovered and named since Evans's original report.

Numerous writers on trypanosomiasis base their diagnoses on the presence of *Tr. brucei*, and, after carefully describing the parasite, state that they do not know whether or not it is identical with *Tr. evansii.* How can such writers, not having previously studied either of the parasites, state that it was not *Tr. evansii* rather than *Tr. brucei* they were working with. If they are positive that the parasite is *Tr. brucei* then they affirm it to be different from *Tr. evansii.* It is obvious that if these parasites are indentical *Tr. brucei* is not entitled to a place in the nomenclature of trypanosoma, for *Tr. evansii* was known and described years before Bruce performed his work. Bruce himself, in his orignal report, considered his parasite probably identical with *Tr. evansii.*

Some eminent authorities criticise Koch and many other writers for stating that *Tr. evansii* and *Tr. brucei* are identical without offering detailed proof of their statements. Such criticism seems to us unjust. The proof demanded is that they are different parasites, and until this proof is furnished, writers, in our opinion, are perfectly entitled to consider the trypanosomiasis of horses and a number of other animals as being due to an infection with *Tr. evansii.*

The practical importance of deciding this question is forcibly brought home to workers in the Philippine epidemic, a fact which has already been emphasized by other writers. We have to deal with an extensive epidemic of trypanosomiasis in several species of domestic animals, particularly in the horse, and the parasite causing the disease seems to be the same in all. This parasite answers the description given of *Tr. evansii*, *Tr. brucei*, and others, and it is necessary either to introduce a new name or to classify from description. We have decided, after a careful review of all available literature pertaining to the subject, that we are dealing with *Tr. evansii*, redescribed by Bruce as the causative agent in nagana and named *Tr. brucei* by Buffard and Schneider, and also described and given other names by various authors. To be consistent with this statement "surra" would be the only allowable popular name for the disease caused by this parasite, the numerous other names becoming mere synonyms.

In those forms of the disease due to other species of trypanosoma other names would, of course, be allowable; but, with the possible exception of dourine, we have nowhere else met so much confusion and such a multiplication of names as is found in the group of which *Tr. evansii* is the cause.

HISTORIC.

Caladrini, according to Voges, in 1842 wrote letters describing a disease in South America which has subsequently been determined to be trypanosomiasis (mal de caderas) and since that time has been discussed under various names and by several authors.

Sivori and Lecler are satisfied that this disease existed in South America before 1850, while Lacerda states that mal de caderas was imported to the mainland about 1850 from Marajo, an island at the mouth of the Amazon River, and from there spread rapidly over Brazil, thence to Paraguay, probably about 1860, quickly covering almost this entire country and killing thousands of horses.

Dourine has been known in various places since the latter part of the eighteenth century, but curiously enough was one of the last varieties to have its etiology elucidated. In 1858 Livingstone wrote of the tsetse fly disease in Africa, at that time old and well known to the natives.

Surra was first brought prominently before the scientific world in a report published by G. Evans in 1880. He accurately described the disease, which had been known for generations to the natives of India, and proved the causative rôle of *Trypanosoma* in this infection. Since the publication of Evans's report a great deal has been written regarding trypanosomiasis, as a glance at the bibliography will show.

The disease annually destroys millions of dollars' worth of animals in India, Africa, and South America. Some of the more recently infected countries are the islands of Mauritius, Java, and the Philippines.

The island of Mauritius was free from trypanosomiasis up to the South African war, but during that conflict many animals from infected countries were sent into Africa and some of them found their way into this island. A severe epidemic developed, destroying so many of the animals that the planting and gathering of crops became an impossibility.

In 1900 surra broke out among the cattle, carabao, and horses of Java, since which time it has there been endemic. As soon as the disease was discovered in Java vigorous plans to prevent its spread were instituted, and with marked success, if the small losses of that country are compared with the frightful havoc among horses and cattle which have been reported from other infected regions.

In 1886 Biguami and Celli mentioned a parasite resembling *Tr. lewisi*, which they found in the blood of a patient suffering from malarial fever. Nepveu, in 1898, reported the presence of *Trypanosoma* in the blood of seven patients, six of whom were suffering from malaria and the seventh was healthy. He described and illustrated the parasite. During 1902 Dutton, Forde, and Manson reported *Trypanosoma* in human beings, and in 1903 Manson and others have reported a number of cases.

The first published report which we have of trypanosomiasis in the Philippines was by Smith and Kinyoun, in 1901. The history of the epidemic in this country has been reported by Musgrave and Williamsons in a preliminary report on trypanosomiasis of horses in the Philippine Islands, published as Bulletin No. 3, bureau of government laboratories. This report was read before the Manila medical society, and brought out considerable discussion. The only point at issue was our statement that the disease was introduced here in 1901. We have investigated, as far as possible, the arguments brought forth that surra was here prior to that time, but have found nothing to justify any change in our original statement. The subject is not of great importance one way or the other, except for its historic interest. There is one thing absolutely certain—that the disease was introduced at that time, and, whether this was its original appearance or not, the frightful epidemic which has raged here is positively connected with this infection. Our statements regarding the manner of its spread were absolutely convincing at the time of the publication of the preliminary report, and additional work along these lines has since confirmed the conclusions there given.

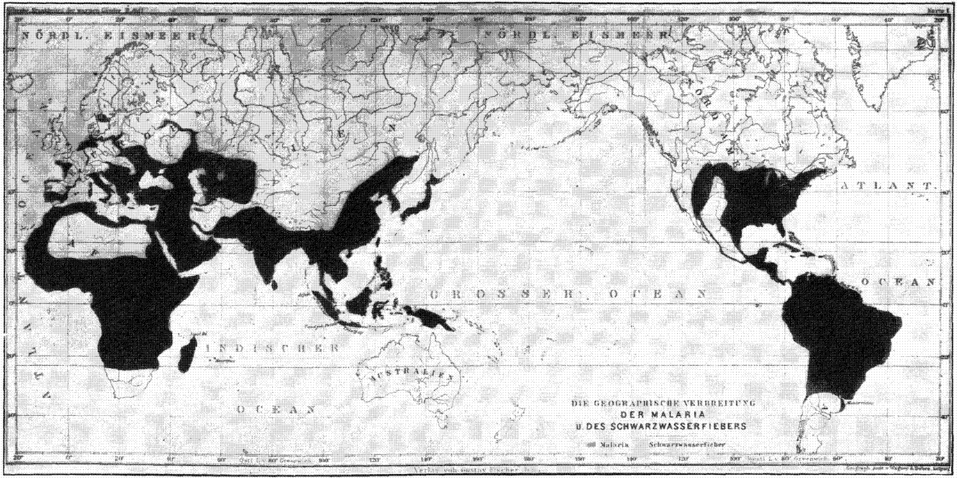
During the past month we have had proof of the reimportation of the disease, this time in a cow received from Java.

Since its introduction the infection has been spreading throughout the archipelago, and at the present time areas in which it is prevalent are reported from almost the entire group of islands.

ETIOLOGY.

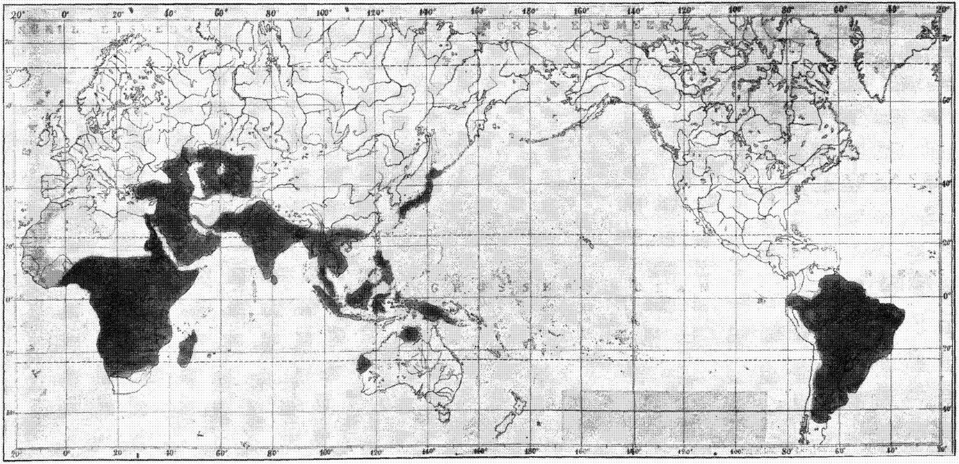
Geographic distribution.—The geographic range of the various forms of trypanosomiasis is shown in the following table:

Continent.	Country.	Province, territory, division, district, etc.	Form.	Reported by—
Asia	India	Bengal	Surra	Lingard.
		Berars	do	Do.
		Bombay Presidency	do	Do.
		Burma	do	Lingard, Steel.
		Cashar	do	Lingard.
		Kohat	do	Lingard, Gunn.
		Konkan	do	Lingard.
		Kumaon Province	do	Do.
		Naga Hills	do	Do.
		Manipur	do	Do.
		Northwest Provinces	do	Do.
		Punjab	do	Lingard, Evans.
		Rajputana	do	Lingard.
	Annam	Cochin China (Tonkin).	do	Blanchard, Mollereau.
		Indo-China (Nha Trang).	do	Carougeau.
	Korea		do	W. G. Campbell.
	Persia		do	Haig.
	Syria		Dourine	Nocard and Leclainche.
	Java	Bantan	Surra	Paszotta.
		Cheribon	do	Do.
		Deli	do	Vrijburg.
		Rembang	do	Penning.
		Semarang	do	Do.
		Soemedang	do	Hubenet, De Does.
		Tegal	do	Paszotta.
	Philippines		do	Smith and Kinyoun, Slee, Curry, Salmon and Stiles, Strong, Musgrave and Williamson.
Africa	Algeria		Dourine	Chauvrat, Merche, Signol, Viordot, Lacquerrain.
	Abyssynia		Surra	Bruce, Hallen.
	English East Africa.		Nagana	Story.
	Egypt		Surra	Lingard.
	German East Africa.		Nagana	Koch.
	Kongo		do	Scloss.
	Madagascar		Surra	Lingard.
	Mauritius		Nagana	Edington.
	Morocco		Dourine	Bruce, Nocard, and Leclainche.
	Nubia		Nagana	Hallen.
	Somaliland		do	Brumpt.
	Soudan		do	Schilling, Dupuy, and Pierre.
	Togo		Surra	Koch, Schilling.
			Nagana	E. Martini.
	Tripoli		Dourine	Nocard and Leclainche.
	Transvaal		Nagana	Theiler.
	Zambesi		do	Livingstone.
	Zululand		do	Bruce.
	Malarial Zone (see map).		do	Do.
Europe	Bohemia		Dourine	
	France		do	Weber and Nocard.
	Germany		do	Legrain.
		Celle	do	Haverman, Hausmann, and Pfannenschmidt, Voges.
		Trakehnen	do	Hertwig.
	Hungary		do	Nocard and Leclainche.
	Spain	Pyrenees	do	Weber and Nocard.
		Navarra		Nocard and Leclainche
	Turkey		Dourine	Do.
South America	Argentine	Catamarca	Mal de caderas	Sivori and Lecler.
		Chaco	do	Do.
		Corrientes	do	Do. Voges.
		Formosa	do	Sivori and Lecler. Voges.
		Misiones	do	Sivori and Lecler. Voges.
		Santa Fe	do	Do.
	Bolivia	Matto Grosso	do	Do.
	Brazil		do	Rebourgeon. Sivori and Lecler.



THE GEOGRAPHIC DISTRIBUTION OF MALARIA AND OF BLACK-WATER FEVER (COPIED FROM SCHEUBE).

M 10 U



SHOWING GEOGRAPHIC DISTRIBUTION OF TRYPANOSMIASIS.

M10U

Continent.	Country.	Province, territory, division, district, etc.	Form.	Reported by—
South America	Chile		Mal de caderas	Voges.
	Marajo Island		do	Lacerda.
	Paraguay		do	Thompson. Sivori and Lecler.
	Uruguay		do	Do.
North America			Surra	Lingard.
		United States	Dourine	Nocard and Leclainche, reports of the Bureau of Animal Industry.
Australia			Surra	Lingard.

Figure 55 gives a schematic representation of the infected areas, drawn from Scheube's map (fig. 3) illustrating the regions of the world in which malaria prevails. Figure 56 is intended to show the relation in geographic distribution of trypanosomiasis and malaria.

The table and maps given above illustrate the wide geographic distribution of trypanosomiasis and its special prevalence in the tropical and subtropical zones. New points of infection are being reported from time to time. Neither the table nor the maps are complete, and both may contain some inaccuracies, owing to the conflicting reports and the fact that some of the references given are not available.

Climatic conditions.—All the different forms of this disease are infections incident to the periods of wet weather. This statement is made in all discussions of the subject which we have been able to review. The reasons given for the fact are varied, but the true explanation, namely, that biting flies are much more numerous during this season than during any other, is confirmed by nearly all recent writers. Not only this, but the rainy season offers another and equally important condition, which will be fully discussed under modes of transmission, i. e., the dark, cloudy days with great relative humidity make it possible for the fly mechanically to carry the infection for a much longer time. We have shown conclusively that bright sunlight quickly destroys *Trypanosoma;* and even if the proper flies were more numerous during dry weather this factor alone would greatly limit their ability to carry infection.

To sum up, the transmission of the disease is greatest exactly under the climatic conditions most favorable to insect life and to the insect's ability to carry the living infection. Such conditions occur in low-lying, marshy lands during the dark, cloudy days of the rainy season.

Trypanosomiasis prevails to a limited extent under other circumstances, but we have reason to fear epidemics only when those above described are realized.

We know of no other predisposing causes for surra. All species of animals within certain geographic zones may contract the disease by experimental methods. As will be shown, natural infection is a mechanical process, so that no reason exists against the supposition that all animals are susceptible to the usual methods of transmission.

A number of writers have stated that a greater percentage of foreign horses coming into an infected zone than of native animals contract the disease.

Of 80 horses observed by Lingard, 16 per cent died during the first year, and 70 per cent during the first seven years while under observation. Australian horses were found by him to be more susceptible than the native horses of India.

In our experience in Manila, Australian, Chinese, and American horses do not appear more susceptible than native ponies. In several instances we have been able to observe the infection in large stables containing both native and American horses, and under these conditions one appeared to contract it as readily as the other. The greatest percentage affected in either case is always found in large groups of animals; and as American horses are more frequently collected in large stables, a superficial deduction from this fact might be misleading. In reality, the higher percentages we have encountered have occurred in stables containing native ponies.

Lingard considers both sexes to be equally susceptible. We have had no opportunity either to confirm or to disprove this statement, as nearly all the horses in Manila are males. Sex certainly plays no part in the communication of the disease in other animals, and there is no reason to suppose it would do so in horses.

In 1885 Steel stated that white and gray mules are more susceptible to surra than darker colored animals, and, among others, Laveran and Mesnil believe this to be the case with horses as well. They attribute this phenomenon to the supposed fact that flies bite light-colored animals more readily than dark ones. This fact is questioned by some authors, although it is true that on the former animals the flies may be more noticeable than on the latter. We have been unable to verify this statement. White and gray animals have not been infected in greater proportion than others, nor do they more readily attract biting flies. As a matter of fact, our statistics of the Philippine epidemic show them to be less frequently attacked. No importance can therefore be attributed to color as a factor in the spread of the disease.

In general, no material difference in the percentage of infection in horses of varying ages has been found. The greater proportion of animals in Manila are older than four years. Our investigation of rats has shown us that the older animals contain *Trypanosoma* more often than the younger ones. The difference is probably not due to the greater susceptibility of the former, but is accounted for by the fact that, like dogs, they are prone to fight, and hence very frequently have wounds, particularly about the head, which naturally favor the entrance of the parasites.

TRYPANOSOMA.

Historic note.—In this discussion the species of *Trypanosoma* have been followed in part at the expense of the chronologic order of publications.

Valentin (1841) discovered a *Hematozoon* and Glugge (1842) parasites, the former in trout (*Salmo fario*) and the latter in the blood of frogs. Both were probably *Trypanosoma*, Doflein considering Glugge's description sufficient for the recognition of the genus. In 1843 Gruby observed a flagellate infusorium in frogs, naming it *Tr. sanguinis;* and despite the previous work of others, he has generally been credited with its discovery, his work being subsequently confirmed by a number of investigators.

Lankester (1871) discovered a sausage-shaped parasite in the blood of frogs, naming it undulina. Gaule (1880) made some further observations on these bodies, which he considered protoplasmic portions of the blood corpuscles separated for a short period of independent life and more prevalent in very dry, warm weather. Leucocytes were seen to be converted into flagellates and then back to leucocytes. Bütschli and Lankester, commenting on Gaule's work, stated independently that the conversion of ameboid bodies into flagellates and the reconversion of flagellates into bodies resembling white corpuscles did not prove the latter to be leucocytes.

Grassi (1882) observed in frogs a parasite which was named paramecioides.

Blanchard (1889) confirmed Gruby's work and gave the following synonyms: *Paramecium loricatum* Mayer, 1843; *Ameba rotatoria* Mayer, 1843; *Globularia radiata* Wedl, 1849; *Paramecium costatum* Chaussat, 1850; *Undulina* Ray Lankester, 1871; *Paramecioides costatus* Grassi, 1882; and *Hematamonas* Mitrophanow, 1883.

Danilewsky (1885) described at least six varieties of parasites in the blood of frogs. He noted the change in the blood at rest from the flagellate to the ameboid stage, as had already been mentioned by others. Ameboid forms were seen to segment into sixty-four spores, which gradually assumed monad forms and divided by longitudinal division. Transverse division also was occasionally seen. Flügge (1896) stated that these parasites very closely resembled *Tr. lewisii.* Multiplication consisted in longitudinal and transverse division and spore formation, the latter sometimes being preceded by an ameboid stage. He gave the length as 80 microns and mentioned that the parasites were provided with an undulating membrane and flagella. He said that they were found in frogs, tortoises, fish, birds, oysters, chickens, and geese. In general structure they resembled *Trypanosoma.* Their pathogenic action was not known.

Koninski (1901) again called attention to the probability of an increase in the occurrence of *Tr. sanguinis* Gruby with the age of the animals. They were found at all seasons of the year and are more common in males than in females. No disease was produced in frogs, and there was no evidence of the mode of transmission in these animals even when they were kept together for months.

Eberth (1861) discovered in the intestines of birds a parasite which was named by Kent *Tr. eberthii,* but which, in all probability, was a *Trichomonas.*

Lewis (1878 and 1879) described *Trypanosoma* found in the rats of India. In a second paper, published in 1884, he considered these *Trypanosoma* identical with *Tr. evansii.* Opie, Flügge, and some other writers give the credit for discovering *Tr. lewisii* to Osler, but we have been unable to verify the reference, and Osler does not indicate that such is the case in his article on the *Hematozoon* of malaria (B. M. J., March 12, 1887) in which he reviews the work of Lewis and others on *Trypanosoma.*

Bütschli (1880) found flagellates in the intestinal canal of a nematode (*Tribolus gracilis*) and also in the intestines of domestic flies. Including flagella they measured about 33 microns in length and were sometimes observed in stellate colonies.

Wittich (1881) discovered in the blood of hamsters a *Trypanosoma* which he considered identical with *Tr. lewisii.* This observation was confirmed by Koch. Wittich's work was done in Germany on twelve hamsters imported from Africa. He states that his organism agrees in all respects with Lewis's description of the *Trypanosoma* of rats in India. Eleven of his hamsters died; but he did not consider

Trypanosoma to have played any part in the malady to which they succumbed, although present in all.

G. Evans (1880) discovered *Trypanosoma* in the blood of horses suffering with the well-known surra of India. He proved the causative agency of these parasites in the production of the disease. Steel (1885) confirmed Evans's work, and named the parasite *Spirocheta Evansi.* Crookshank (1886) made a report on these parasites, confirming Evans's and Steel's work. He considered these *Trypanosoma* identical with Mitrophanow's *Trypanosoma* of carp.

Kent (1881) discovered "*Herpetomonas*" in the intestines of the domestic fly. His parasite had no undulating membrane and was probably not a *Trypanosoma.*

Certes (1882) found in the digestive tube of an oyster a parasite which has been named *Tr. balbianii.* The general description follows that of *Trypanosoma*, but slight differences of internal structure were noted. Undulating membrane and flagella were present, but nucleus, nucleolus, and vacuole were not observed. In a later paper he demonstrated a nucleus. He considered this *Trypanosoma* closely related to Mitrophanow's "*Hematomonas*" (*Trypanosoma*) of fish. Laveran and Mesnil (1901) found these parasites rarely in Portuguese oysters and frequently in common oysters. They say that the bodies were not flagellate and that the presence of an undulating membrane was questionable. They do not consider Certes's organism a *Trypanosoma*, but rather a bacterium.

Mitrophanow (1883) described *Trypanosoma* in mudfish (*Cobatus fossilis*). His parasite was 1 to 1½ microns broad and 30 to 40 microns long. He gave a very careful description of this organism, which occurred in nearly all the fish examined and was more numerous in hot than in cold weather. He gave the group the name "*Hematomonas*" and described two species.

Moebius (1883) found *Trypanosoma* in oysters (*Tapes decussata* and *Tapes pullastra*). These parasites were studied by Lustrac (1896), who considered them *Trypanosoma.*

Marchifava and Celli (1885) found in the blood of a patient with malarial fever parasites very closely resembling the *Trypanosoma* of frogs, birds, und fish. Nepveu (1898) described *Trypanosoma* in seven cases occurring in men, six of whom were suffering from malarial fever. Barron is quoted by Laveran as having seen flagellates in the blood of an anæmic woman. During 1902, Dutton, Forde, Sambom, Manson, and others have described the occurrence of *Trypanosoma* in human beings. Dutton first published an account of these parasites, found in the blood of Doctor Forde's patient.

Danilewsky (1890) found a *Trypanosoma* in the blood of birds, naming it *Tr. sanguinis evansii.* Like Bütschli's parasite, it had a long flagellum and an undulating membrane. Division was longitudinal, transverse, or by segmentation from the ameboid stage. No symptoms were produced in the host. Danilewsky thought this probably due to the high temperature of the birds or the tolerance acquired by generations of infection.

Laveran and Mesnil (1901) found *Trypanosoma* in three kinds of fish—brochet, sole, and redeye. That found in the brochet they say closely resembled *Tr. evansii*, etc., and was named by them *Tr. remakii*, after Remak, who, they say, first observed the parasite in 1842. The *Trypanosoma* from the sole was also of the same general type, and they designated it as *Tr. soleæ.* Laveran and Mesnil state that *Trypanosoma* had not previously been observed in salt-water fish, but in this they are probably mistaken, for Flügge (1896) reported finding them in the fish of the Mediterranean Sea. The organism which they found in the redeye had a flagellum at each end. They placed it in a separate genus, which they called *Trypanoplasma*, giving the parasite the name *Trypanoplasma borrelii.*

Rouget (1896) described *Trypanosoma* found in the blood of a horse suffering from dourine (beschälseuche), and for two and one-half years continued the study of this organism in susceptible animals. Wasilewsky and Senn (1899) confirmed Rouget's work, and determined the pathogenic action of this *Trypanosoma* for the horse, passing it through other animals and back to the horse, reproducing the disease. Voges says that this *Trypanosoma* was discovered by Chauvrat in 1892.[a] Laveran and Mesnil (1901) proposed the name *Tr. rougetii* for the parasites of dourine. Doflein (July, 1901) named it *Tr. equiperdum*, which is the name used also by Salmon and Stiles.

Elmassian, according to Voges, in 1901 first differentiated the *Trypanosoma* of mal de caderas in South America, while Voges (1902) very carefully described the parasite, proved its pathogenic action, and named it *Tr. equinum.*

Theiler, in an article published by Bruce (1902), is credited with the discovery of a new *Trypanosoma* of cattle in South Africa. Bruce proposed the name *Tr. theilerii.*

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[a] Reference not available.

During the same year Theiler found a different species of *Trypanosoma* in the cattle of the Transvaal, sending specimens of it to Laveran, who bases his statement that it is a distinct genus, particularly on the location of the centrosome near the center of the body, close to and sometimes united to the nucleus. He proposed the name *Tr. transvaaliense* for this parasite.

In 1901 Smith and Kinyoun described a parasite which had been observed by Doctor Jobling in the blood of a sick horse in Manila, and this parasite was afterwards determined to be a *Trypanosoma*. Later in the same year Smith made some additional notes on the organism and considered it *Tr. evansii.*

Curry (1902) described the parasite and classed it as a *Trypanosoma*, but was unable to state whether it was *Tr. evansii* or *Tr. brucei.* His description was the first accurate one of the parasite found here.

Technique for the study of Trypanosoma.—For the determination of the presence of *Trypanosoma* in the blood only a fresh preparation, such as is used for the examination for malaria, is needed. The parasites, where numerous, are readily observed with a DD, or even an AA, objective and No. 4 ocular Zeiss. If they are scarce, considerable time may be necessary to find one, but once seen the diagnosis is easy, and may be facilitated by staining the specimen by any of the approved methods. For a careful study stained specimens are essential.

Fairly good results are obtained by any of the methods used for staining malarial parasites. Romanowsky's method, or any of its modifications, particularly Wright's, gives beautiful pictures. Laviran and Mesnil have also published directions for making an excellent stain.

A most satisfactory stain for *Trypanosoma* is one prepared by Dr. Paul G. Woolley, pathologist in this laboratory, and published here for the first time with his permission.

Fix smears in absolute alcohol for ten minutes.

A.—Eosin (w) (Grubler)	grams	1
Distilled water	do	1,000
B.—Polychrome methylene blue (Unna).		
C.—Methylene blue (Med.) (Grubler)	do	1
Distilled water	do	100
D.—Of solution B	parts	2
Of solution C	do	1

Mix and add 1 c. c. of A to each 4.5 c. c. of D.

Stain by immersion for twenty to thirty minutes. Wash with water. Wash for two to five seconds with solution A and blot immediately.

The effects on protoplasm and nuclear material may be regulated by longer and shorter exposure to the eosin solution in the last step.

Life cycle.—Salmon and Stiles write of flagellates as follows:

"In general, but especially in reference to the lower forms, it may be said that the protoplasm is quite homogeneous. A nearly fluid endoplasm may be recognized surrounded by a peripheral ectoplasm. The latter in turn may be bounded by a more dense layer, like a delicate cell membrane. These three divisions are, however, not always very distinct, but grade almost imperceptibly into one another. The pharynx is a very superficial infundibulum. A permanent anus appears to be absent, but the excreta appear to be expelled from a less resistant point at the posterior extremity, without, however, leaving any trace of their passage. The flagellum represents an organ of locomotion, and there may be one or more present. The pulsating vacuole is near the surface, but does not appear to possess either a distinct membrane or a permanent pore. The nucleus is rounded and appears to be provided with a nuclear membrane and nucleolus. If conditions become unfavorable, as when the medium becomes too condensed by evaporation or too toxic by extreme putrefaction, the flagellate may discard its flagellum, become round, and form a surrounding cyst membrane. Upon return of favorable conditions it may escape from the cyst, and, forming a new flagellum, recommence its active life, or it may divide during encystment. The division of the free form in multiplying is usually longitudinal. In some cases the organism encysts before dividing. Then, by a longitudinal division, two organisms are formed. The latter may then escape, form their flagella, and become active, or each daughter organism may reencyst and divide further, or the mother flagellate, when encysted, may divide into a large number of so-called 'spores,' each of which, upon escaping, forms its flagellum. There may also be a complete conjugation of the two individuals, followed by encystment and division into numerous young."

The illustration (fig. 57), taken from Doflein, is intended to show the variations in the life cycle of the flagellates.

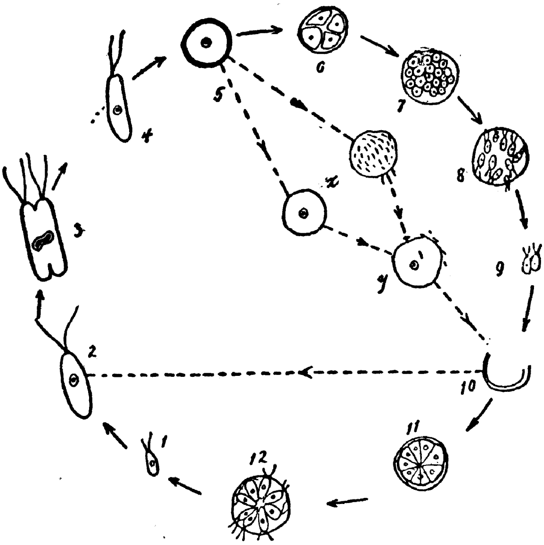

FIG. 57.

But little is known with reference to that of *Trypanosoma*, and the majority of writers so express themselves. However, a number have observed in the blood bodies of various kinds, which they have considered as having to do with the phase in the cycle of development. Voges and others consider the entire life cycle of the parasite to be acted out in the blood and present very good arguments in favor of their conclusions. Schat is the only author, among those whom we have been able to review, who believes in an intermediate host for the parasites.

He says: "Analogously to what is known to be true in malaria, it appears that the surra parasite also goes through a cycle of sexual development in the body of the fly, and in that of the horse, cow, and donkey an asexual one. The asexual development may be of two kinds, one the formation of spores and the other division.

"In the blood of horses or cows and in that of our experimental animals we have not observed during the whole course of the investigation a sexual union of the parasites, which is contrary to the observations of Penning and Plimmer and Bradford, who make mention of forms of conjugation.

"In this regard we feel justified in supposing that an hypothesis similar to that which Manson proposed for malaria holds true also in the case of surra; that is, a blood-sucking insect (the *Stomoxys*) serves as a host in this disease also, and that the surra parasite is propagated in the body of this insect outside of the horse and cow." Fig. 58 taken from this author illustrates his observations.

We are inclined to accept Voges's idea of the life cycle. *Trypanosoma* have not been found living outside the animal for any considerable length of time; the removal of the animal host from a locality always results in the disappearance of the disease, and attempts permanently to infect media of any kind have usually proved unsuccessful. We have performed a number of experiments with biting flies caught on sick animals, and have failed to convey the disease after twenty-four hours, either by allowing these flies to bite susceptible animals, or by injecting or feeding emulsions of these insects during their lifetime. This, of course, argues against the probability of any but a short life cycle in these insects.

Recently Novy has reported the cultivation of *Tr. lewisii* for over a year, without any loss in their virulence, in a medium composed of agar and rabbit's blood. Only very brief mention of this report has been received, and we are unable to determine what is meant by "no loss of virulence" in *Tr. lewisii*. The work is interesting and the results would seem to furnish further evidence that an intermediate host plays no part in the life cycle of *Trypanosoma*.

General character.—Trypanosoma of all species are in general similar organisms. The family diagnosis, as given by Salmon and Stiles, is as follows:

"Flagellate parasitic forms with one chief flagellum directed anteriorly; in some forms a secondary flagellum directed posteriorly; body usually with two angles, and wound more or less in the form of a spiral; one angle of the body provided with an undulating membrane. One nucleus and one centrosome present."

The morphology varies greatly in the same species of *Trypanosoma*, and also to a greater extent in different species. In general the parasites may be said to measure from 1 to 5 microns in thickness and from 15 to 45 microns in length, including flagellum. They all show very active eel-like movements and some motility. In some species the latter is very slight, the parasites undulating with extreme rapidity but covering so short a distance as to be easily followed under the microscope; while in others, especially *Tr. lewisii*, the movements are often so rapid in freshly drawn blood that it is impossible to keep the parasite in the field. Some writers have used these variations in motility as a diagnostic point in differentiating the organisms, and in general some importance may be attached to it; but there are so many exceptions, due to conditions which are not understood, that its value in differential diagnosis may partly be disregarded. Variations are occasionally found in one species, often indeed in a single preparation, which are nearly as great as those observed between different species.

The flagellum at the anterior end of the parasite, in all forms which we have studied, varies greatly in length. It is always actively motile, pointed, and continuous, with the thickened margin of the undulating membrane ending at or near the centrosome or micronucleus. It may be entirely homogeneous, or it may contain from two to several distinct granules extending well out from the body of the parasite.

The undulating membrane extends along one border of the organism from near the centrosome in the posterior portion to the anterior end of the parasite, from where it continues as the free flagellum. Its breadth and folds vary considerably in the same and in different species of parasites, and also, no doubt, to a considerable extent with the age of the *Trypanosoma*. Many authors assert that the young forms are entirely free from this membrane.

The nucleus is usually situated in the anterior half of the parasite and varies considerably in size and shape. It is generally oval or round, and assumes other contours with the different stages of division.

The centrosome is usually in the posterior and more blunt end, and appears to have an intimate association with the flagellum and undulating membrane. Its varying distance from the posterior end has been used as a diagnostic point in determining the species, but not much importance can be attached to it, for it has been shown that the posterior end of the *Trypanosoma* is undoubtedly contractile, so that the distance from the extremity at which the centrosome is found, and also, to a certain extent, the degree of bluntness of this part—a feature which has been so much discussed depend partly upon its contraction or elongation at the time of fixation for staining and study.

The protoplasm is homogeneous or granular, depending upon the age of the parasite, its environment, and no doubt to a certain extent upon the species. The granules may vary in number and size from a very few small ones situated in the anterior portion of the *Trypanosoma* to numerous large ones scattered throughout the protoplasm.

Multiplication.—Voges gives three forms of multiplication, i. e., longitudinal and transverse fission and segmentation. He did not observe conjugation. The chromatin divides into from 3 to 10 segments, which assume irregular shapes and locations, and some of which are often found well up in the flagellum. The nucleous usually divides into equal parts, but may break into several segments. After division the protoplasm may assume various irregular forms. The young nuclei arrange themselves in groups, and the parasite twists and splits by longitudinal or more often by transverse fission. The new division forms are often bowl-shaped, but gradually assume their regular outline. Sometimes a parasite assumes the appearance of a globular mass, nuclei, showing a number of flagella, form around the periphery and division into several segments occurs.

Plimmer and Bradford consider longitudinal and transverse division the more frequent modes of reproduction, although they observed also conjugation, which consisted in the fusion of the micronuclei, followed by an ameboid stage and division by segmentation. The ameboid stage at times occurred independently of conjugation.

Martini, who has recently worked with *trypanosoma* obtained from an infected pony imported to Berlin from Togo, gives five stages of multiplication as follows: First stage: Broadening out of the chromatin grains of the nucleus; flagellum thickens; nucleolus appears to be a thick streak; chromatin granules loosen. Second stage: Two chromatin heaps; two nuclei; pairs remain together; beginning division of the undulating membrane. Third stage: Two distinct membranes seen. Fourth stage: Two flagella, one slightly shorter than the other. Fifth stage: Young *trypanosoma* attached only at the posterior end. Sometimes one of these is already seen in the process of fission.

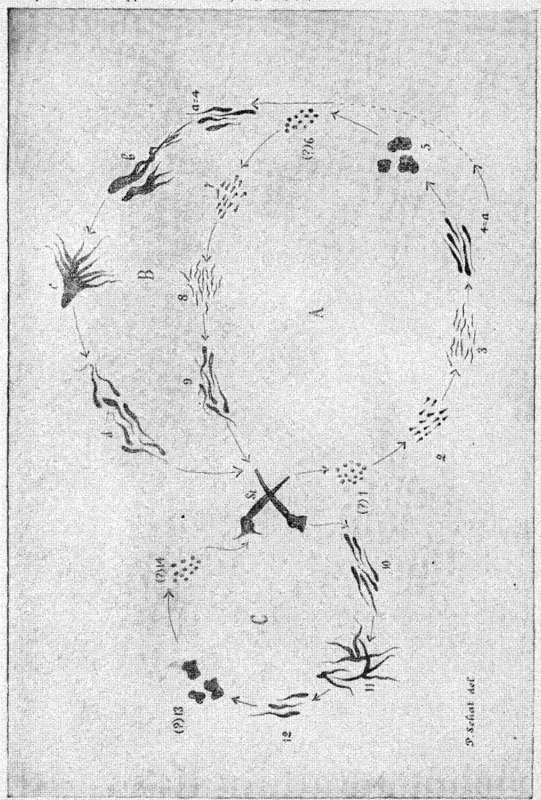

FIG. 58.

Illustrating the life cycle of *Trypanosoma*. (After Schat, 1901.)

Explanation of figure 58.

Circle A gives a schematic representation of the cycle of asexual development of the surra parasite through the formation of spores in horses, cattle, etc.

Circle B the changes in the seuxal development of the surra parasite through partition, in horses, cattle, etc.

Circle C the cycle of sexual development of the surra parasite in the body of the *Stomoxys* fly.

Circle A. (?) 1, spores introduced into the body of a horse, cow, etc., through the bite of a fly; 2, the minute conical bodies which result; 3, the young surra parasites which spring from these minute bodies; 4, the matured surra parasite; 5, the ameboid form which results; 6 (?), the formation of spores; 7, the minuteconical bodies; 8, the young surra parasite; 9, the matured surra parasite.

Circle B.—*a, b, c, d* represent forms of partition; *St*, the sucking and biting instrument of the *Stomoxys*.

Circle C.—10, the surra parasite in the stomach of the *Stomoxys*; 11, process of conjugation in the stomach of the *Stomoxys*; 12, the surra parasite produced; 13, 14, not yet observed, but are probably the subsequent stages of development in the body of the fly.

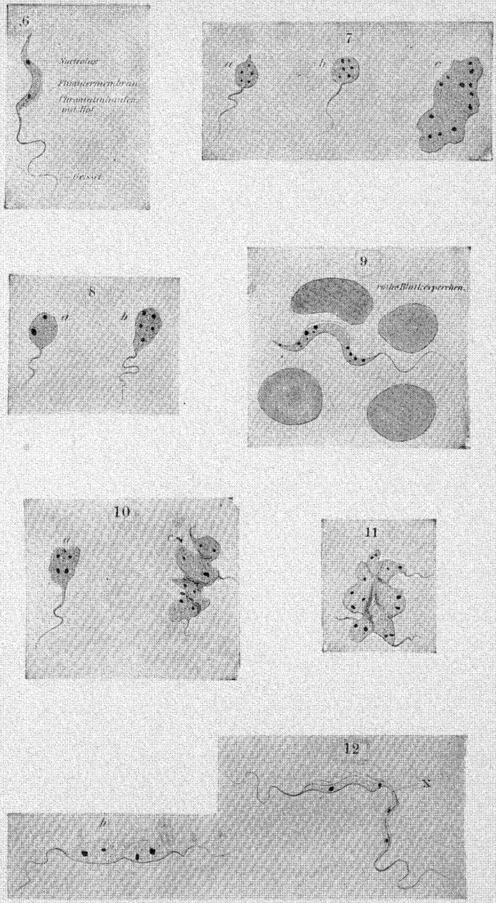

FIG. 59.

Nos. 6-12.—6, Young adult *Tr. equinum;* 7, degeneration forms; 8, young *Trypanosoma;* 9, multinuclear adult *Trypanosoma;* 10*a*, longitudinal division; 10*b*, transverse division; 10*c*, multiple division; 11, irregular form; 12, two young *Trypanosoma* not yet separated. (After Voges, 1901.)

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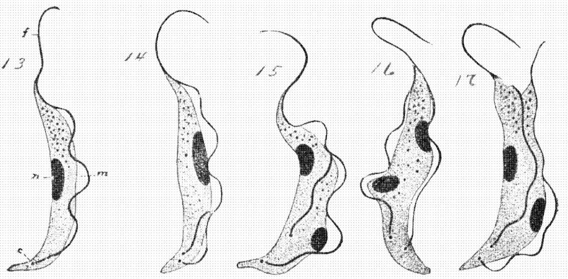


FIG. 60.

Nos. 13–17.—13, *Tr. brucei* (*n*, nucleus; *c*, centrosome; *m*, undulating membrane; *f*, flagellum); 14, beginning division, showing two centrosomes and partial division of flagellum; 15, 16, 17, further stages of division. (After Laveran and Mesnil, 1901, figs. 1 to 5.)

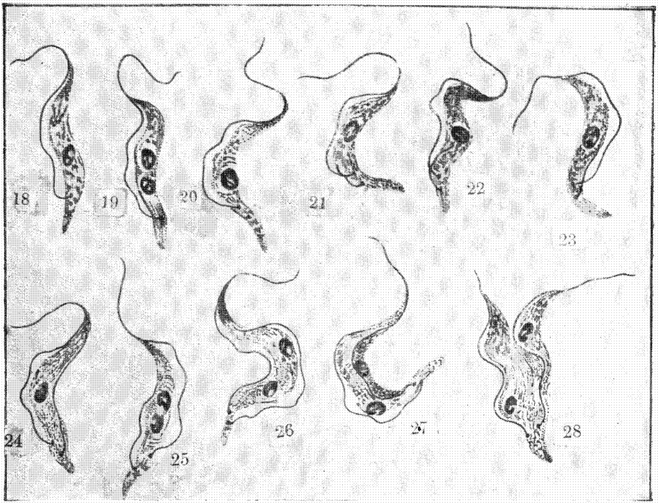
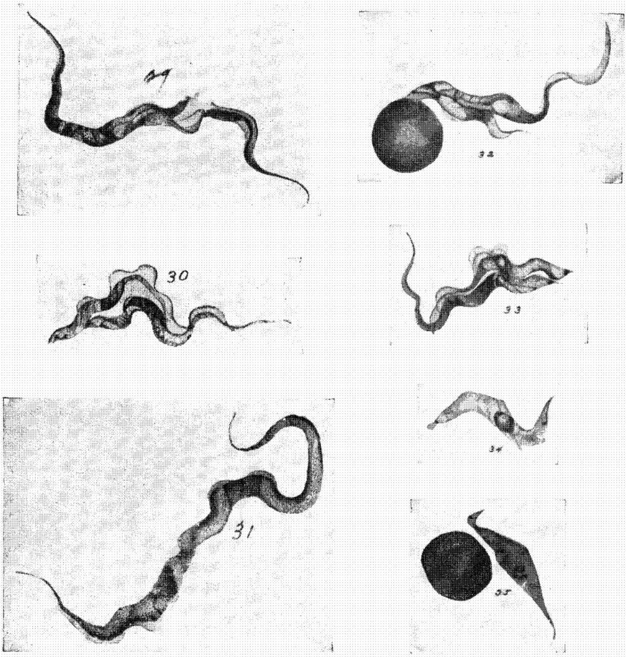


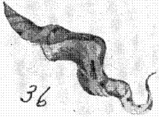
FIG. 61.

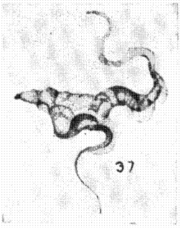
Nos. 18–28.—*Tr. equinum*, showing various stages of division. (After Sivori and Lecler, 1902, Pl. III.)

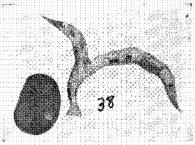
18, *Trypanosoma* with two chromatin corpuscles of the flagellum; 19, *Trypanosoma* with two nuclei; 20, *Trypanosoma* with a nucleus, two chromatin corpuscles, and a short flagellum, which starts from the posterior chromatin corpuscle and is united or not to the other flagellum; 21–24, *Trypanosoma* with a large nucleus, slightly elongated, two chromatin corpuscles; two flagella, one shorter than the other and united to it or not; 25–27, large *Trypanosoma* with two separate nuclei. The protoplasm is accumulated toward the poles of the nuclei and is rarer in the middle. Two flagella, one longer than the other, or equal and separate; 28, *Trypanosoma* similar to the preceding, but the flagellated or anterior extremities have begun to separate.

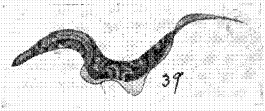


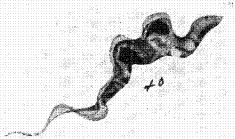
FIGS. 62, 63.
Nos. 29–35.

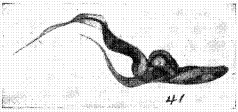












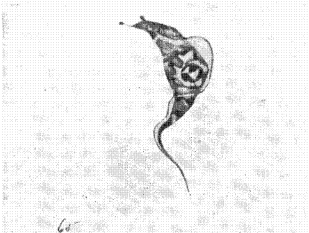


Figure 64. Showing a peculiar phase of multiplication (Tr. evansi)

FIGS. 64, 65.

Nos. 36–42.

He did not observe any other forms of multiplication or conjugation.

Schilling did not see multiplication forms in the circulating blood in connection with surra in Togo. He considers the mode of division to be influenced by the number of chromatin granules found in the parasite and to be usually by longitudinal fission. He did not observe ameboid forms or conjugation. He gives two stages in the usual mode of multiplication. In the first one a double undulating membrane is seen, and in the second the whole undulating membrane divides longitudinally and gradually separates the parasite, the posterior end being the last to part. Young forms have no undulating membranes. Daughter parasites are always smaller than the parents.

Laveran and Mesnil have studied the forms of multiplication very carefully and consider that with the *Trypanosoma* of nagana, multiplication in the blood is by longitudinal division only and into young of equal size, which are also nearly as large as the adults.

Dividing forms are always present in the blood, and just before division begins the parasite increases in size. The order of division is as follows: (1) Centrosome, (2) flagellum, and (3) nucleus and protoplasm. The centrosome first elongates and divides into two round bodies followed by a division of the flagellum. The nucleus increases in size. New nuclei are then formed by direct division. The protoplasm follows the nucleus in separation and may begin at the free end. Two parasites may remain attached at the posterior ends for some time after division, and both may then divide again before separation is complete. These authors have not yet seen the young forms of Kanthack, Durham, and Blandford, or the ameboid forms of Plimmer and Bradford. They give some variations from the parasite as described by Lewis, but this point will be more fully discussed under "Differential Diagnosis of *Trypanosoma*."

Sivori and Lecler agree with Laveran and Mesnil as to the modes of multiplication illustrated by fig. 61, 18–28.

Rosette formations of *Trypanosoma* have been extensively noticed, but considerable difference of opinion as to their cause has been expressed. Some consider them as entirely a multiplication phase, others as agglutination, while the majority agree that such formations may be the result of either of these phenomena. There certainly can be no question that these figures occasionally result as a phase of multiplication. Rabinowitsch and Kempner compare them to the segmenting malarial parasite.

The methods of reproduction described comprise those of the most importance and represent the views of many of the writers whom we have been able to review. Schat, as has been seen in the discussion of the life cycle of *Trypanosoma*, holds some very original opinions. So far as his work has to do with multiplication, he maintains that the asexual, longitudinal division occurs in the blood of infected animals and that the sexual reproduction takes place in certain flies.

In our studies we have never observed conjugation, and in blood under normal conditions reproduction by transverse division or segmentation is very rare. Longitudinal division is by far the most frequent form, and usually takes place in the order given by Laveran and Mesnil. This is not constant, however, for in the same specimen of the parasites taken from the blood of an infected dog, horse, or other animal, we have seen individuals showing this order and others in which the division certainly differed from the course described by these authors. Figs. 32–35 illustrate this point. Elmassian, working with the South American disease, has recently reported results similar to ours.

The parasites, just before death is evident, usually become thicker, but sometimes this stage is not perceptible. When it occurs, it may proceed to such an extent that the transverse diameter of the *Trypanosoma* will measure from 5 to 7 microns before any other evidence of division can be observed (No. 35). From this point the picture is not constant. In many forms the next change to be noticed is a division of the nucleus into one or more parts (fig. 63, no. 34, 35). The centrosome usually divides first, although in some instances the flagella show beautiful division extending well down into the undulating membrane, without the slightest apparent change in either the centrosome or the nucleus.

Schilling's statement that the mode of multiplication depends upon the number of granules which the parasite contains appears to us deserving of careful consideration. Longitudinal division in an individual containing numerous large granules is rarely seen. These parasites assume numerous shapes and often arrange themselves as if segmentation were in progress (fig. 64, 36–42), and in the majority of cases they are the ones that produce the involution forms.

Agglutination.—Several observers have noted the bunching together of *Trypanosoma* under certain conditions, and have described the phenomenon as agglutination. Some, as has already been mentioned, consider this to be a multiplication phase, while others suppose it to be the natural position assumed by the parasite just before dying. The process has not been seen at all by some of the most careful investigators.

Laveran and Mesnil regard the agglutination of *Trypanosoma* as a phenomenon similar to that produced in bacteria and believe it to be brought about by a number of conditions. Among their reasons for this conclusion they mention the continued motility of the parasites after clumping and the fact that the reaction is most marked with weak specific sera and less so with strongly fortified ones. Rabinowitch and Kempner, how ever, were unable to obtain agglutination with their specific serum. According to Laveran and Mesnil, the reaction may be obtained both with living organisms and with dead ones, and it does not stop the motility of either the individual or the aggregation of parasites.

The reaction always begins in the same way. Two parasites are seen to join by their posterior ends (fig. 67, 45) and from a number of these rosettes are built up the posterior ends of the individuals pointing toward the center and their bodies extending outward like the spokes of a wheel. (Fig. 66, 43 and 46.) Such masses may, under certain conditions, group themselves and form secondary axes. (Fig. 67, 44 and 47.)

Agglutination often occurs in defibrinated blood containing *Trypanosoma* and kept on ice. The serum obtained from a rat partly immunized by the injection of blood containing *Trypanosoma*, when mixed with• infected defibrinated blood, causes agglutination.

Parasites which have been killed or paralyzed by formol, chloroform, or a specific serum are agglutinated by the same agencies which produce the reaction in the living organism.

Agglutinations often are not permanent, and under certain conditions, according to Laveran and Mesnil, "disagglomeration" takes place. In this the secondary formations are first broken up, and then the primary rosettes disunite or lose a part of their elements. They consider this "disagglomeration" to be in inverse ratio to the agglutinating value of the serum employed.

Normal rat's blood has no agglutinative action, but when fortified by inoculations does gain this power. Five to 10 c. c. of trypanosomatic blood injected into a rat will produce a serum capable of agglutinating *Trypanosoma* in defibrinated blood in a dilution of 1–5 to 1–50.

One of Laveran and Mesnil's rats, which in seven months had received 13 inoculations of blood containing *Trypanosoma*, gave a serum which in a dilution of 1–10 so paralyzed the *Trypanosoma* that rosettes were not formed.

Serum exposed to a temperature of 55° to 58° C. during one-half to three-fourths of an hour did not lose its power to agglutinate, but was materially weakened. Exposure to 63° to 65° C. for half an hour completely destroyed its agglutinative properties.

Adult guinea pigs were immunized by several injections of infected blood. Their serum had a feeble agglutinative reaction for *Tr. brucei*. With a similar serum from young guinea pigs no agglutinative reaction was obtained. The serum of a pigeon, guinea pig, or frog did not show an agglutinative reaction for *Tr. lewisii*, but that of a sheep, dog, or rabbit gave a slight one for these parasites. With sera from the horse and the chicken agglutinations were more definite and occurred in dilutions of 1–2 to 1–10.

Of all the animals examined, the serum from the horse was the most active and that of the chicken second, but in both of these the reaction was greater for red blood cells than for *Trypanosoma*. Human serum did not agglutinate *Tr. brucei*, but the sera of guinea pigs and of pigs, which have no curative properties, gave beautiful agglutinations when mixed with trypanosomatic blood. This would seem to prove that agglutinating and curative properties are separate and distinct. Agglutinations once formed had a tendency to disagglutinate in most sera as well as in other substances. In the rabbit this was accomplished at the end of several hours. They persisted best in the sera of the dog and the sheep. Rats immunized by repeated injections of *Tr. lewisii* showed but feeble agglutinative reaction with their own parasites.

According to Rost, surra blood mixed with goat serum in the hanging drop in a moist chamber, killed the *Trypanosoma* in two and one-half minutes, sometimes with agglutination; control parasites were all dead in twenty-three hours.

Sivori and Lecler, in a preparation of horse's blood containing numerous *Trypanosoma*, sometimes observed two, three, and even six individuals or more, united at their posterior extremities and arranged in a radiate figure. The center of the figure was sometimes near a red corpuscle or a leucocyte. The parasites so united preserved their motility. In the blood of a young cat, containing numerous *Trypanosoma* and prepared in a hanging drop, there were visible at the end of an hour eight, ten, or twelve agglomerated parasites. Many of these agglomerations separated after a certain length of time.

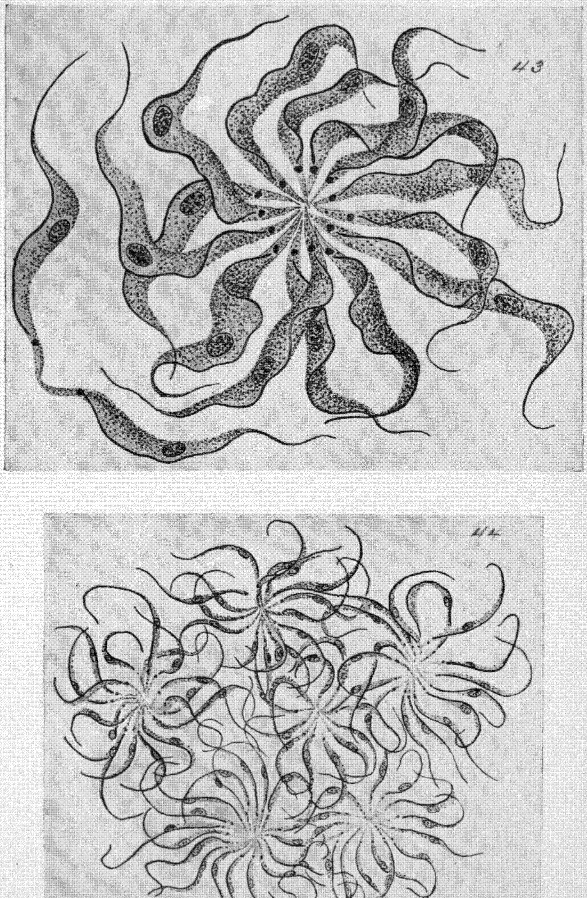


FIG. 66.

Nos. 43–44.—Showing union of two *Trypanosoma:* 43, primary agglomeration; 44, secondary agglomeration. (After Salmon and Stiles, 1902, Pl. II.)

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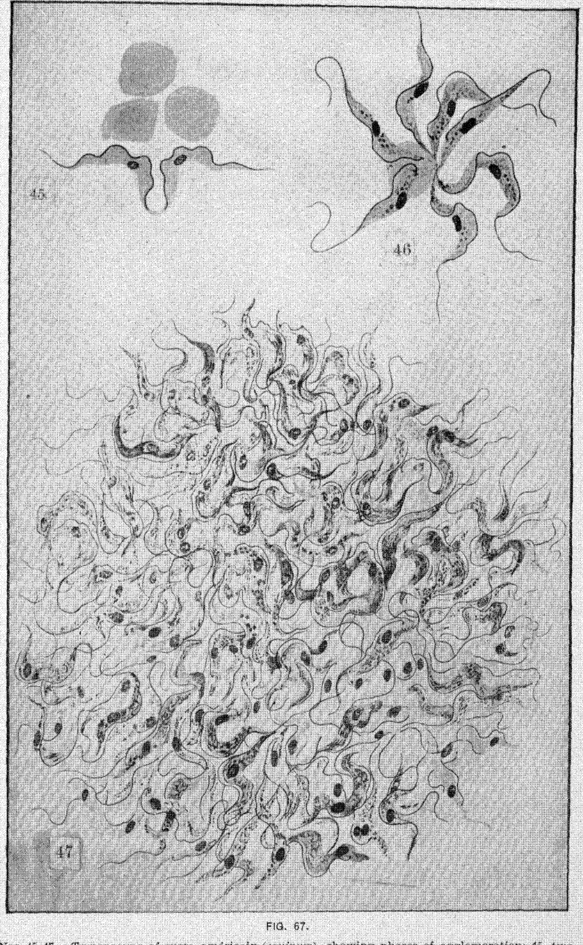

FIG. 67.

Nos. 45–47.—*Trypanosoma* of surra américain (*equinum*), showing phases of agglomeration; 45, two *Trypanosoma* united at posterior extremities, in a preparation made from the peritoneal exudate of a guinea pig twenty-four hours after intraperitoneal inoculation; 46, rosette formation produced by mixing equal parts of infected blood of one horse and serum of another some time before death from surra américain; 47, large agglomeration seen immediately after making the mixture above mentioned. (After Sivori and Lecler, 1902, Pl. 5.)

UofM

M10U

Laveran and Mesnil write: "The *Trypanosoma* of nagana sometimes unite; under certain conditions they form primary agglomerations in rosettes; rarely large secondary agglomerations, which are common in blood containing *Tr. lewisii*, are observed.

"These *Trypanosoma* united two by two would suggest conjugation, but this interpretation is not admissible, as the agglomeration is not observed in pure, fresh blood and is produced only under conditions which may be called abnormal. The number of individuals which agglomerate is exceedingly variable.

"In *Tr. brucei*, as in *Tr. lewirii*, the agglomerations may be seen to separate after varying lengths of time.

"We have seen agglomerations of *Trypanosoma* in the pure blood taken from the heart after one-half to one hour, in the peritoneal exudates after an injection of blood rich in *Trypanosoma* into the peritoneum of rats or mice, and in blood mixed with physiologic water after being preserved for twenty-four hours on ice or heated for half an hour at 41° C.

"On mixing in equal parts the defibrinated blood of a rat or mouse rich in *Trypanosoma* and the serum of a horse, we have obtained beautiful persistent agglomerations. The *Trypanosoma* separated at the end of a few hours. On mixing one part of the serum of a horse and ten parts of blood, no agglomerations were produced. The serum of the blood of a pig also gave beautiful agglomerations.

"The serum of a sheep mixed in equal parts with the blood of a rat or mouse rich in *Trypanosoma*, gave in one case a beautiful agglomeration; in another the agglomerations were not so beautiful and less persistent. The serum of a deer gave small, nonpersistent agglomerations.

"The serum of human blood did not show itself either agglutinative or microbicidal.

"The following sera mixed in equal parts with the blood of a rat or mouse rich in *Tr. brucei* did not show any agglutinative properties: The serum of a rat, normal or immunized against *Tr. lewisii* and agglutinative for these *Trypanosoma;* the serum of a normal chicken; the serum of a chicken inoculated several times with *Tr. brucei;* the serum of a normal goose, and the serum of a goose inoculated several times with blood rich in *Trypanosoma* of nagana.

"If there is added to a few drops of blood rich in *Tr. brucei* a drop of water slightly acidulated with acetic acid, *Trypanosoma* are seen to agglomerate and change their forms rapidly. On adding a drop of water slightly alkalized with soda, no agglomeration occurs.

"*Trypanosoma* when dead still tend to agglomerate, but the process then takes place very irregularly."

Hefferan, commenting on Laveran and Mesnil's statements regarding agglutination of *Tr. lewisii*, doubts the correctness of their observations, giving her reasons for so doing. (Centralb. f. Bakt., etc., Bd. 8, No. 22, May 26, 1902.)

Curry noted that parasites in infected monkey's blood mixed with human blood lost their motility in twenty minutes and agglutinated. Chicken's blood mixed with infected monkey's blood gave similar results.

Schilling states that in cattle immunized with the peritoneal exudate of dogs inoculated with infected blood, the serum killed the *Trypanosoma* on the fourteenth and fifteenth days, and in the hanging drop in from thirteen to twenty-five minutes, but he has little to say of agglutination.

On reviewing the work done on the agglutination of *Trypanosoma* it will be seen that results have been uncertain and inconstant, the subject being left in an unsatisfactory state.

Hefferan's criticisms of Laveran and Mesnil's work in this line, and the statement of Rabinowitch and Kempner that no agglutinations were obtained with their specific serum, throws doubt on all of the results.

So far our work has developed nothing convincing. We have seen the rosettes and other described figures of agglutination, but they have been too inconstant and have occurred under too many conditions to be of any very great significance. Circumstances under which these figures have at one time appeared have at other times produced no results, and they have even occurred under conditions which are not supposed to favor agglutination.

Our results in the agglutination of *Tr. evansi* by various substances described as producing this phenomenon have been at variance with much of the recent work done along this line and more in accord with Rabinowitch and Kempner's conclusions. We have not observed a single condition which constantly gave agglutination figures. Such results were obtained occasionally with various substances, but reactions indistinguishable from these sometimes occur in infected blood without any additions.

A cow was immunized with as much as 3,000 c. c. of infected blood and failed to produce a serum which would agglutinate *Trypanosoma* with any degree of constancy. Similar results were obtained with chicken and human sera as well as with those secured from numerous other sources. Various mixtures of these sera were likewise unsatisfactory. Several chemicals, such as thymol, turpentine, and chloral, would occasionally give what appeared to be agglutination, but no regularity could be observed.

After weighing all evidence in the case and applying our own results, we must conclude with several others that the so-called phenomenon of agglutination is of no value from a diagnostic point of view, and if it is in reality an agglutination, it is too uncertain in its occurrence to serve as an index of immunity or susceptibility.

Involution forms.—Involution forms are produced by surroundings unfavorable to the life of the parasite. Laveran and Mensil mention among the conditions which favor their production (1) the blood of rat rich in *Trypanosoma*, mixed with the serum of some other animal and kept for several hours in a hanging drop; (2) blood containing *Trypanosoma* and heated to 41° to 42° C. for one hour or more; (3) infected blood injected into the abdominal cavity or the conjunctiva of birds and withdrawn after one to three hours; (4) parasitic blood placed in an ice box or in some other way subjected to freezing, and (5) rat's blood containing *Trypanosoma* and treated with arsenic, etc.

The same authors give the following as the principal type of involution forms: Round, flask-shaped bodies, in stained specimens usually showing nuclei, centrosomes, and flagella. If dividing forms have assumed this shape, two nuclei, two centrosomes, and two flagella may be seen. These bodies may form small agglutinations, and it is probable that the latter are what Plimmer and Bradford call plasmodic forms. Flask-shaped *Trypanosoma* are not always dead when not moving, as they may still be capable of conveying the disease to rats.

Trypanosoma in dying undergo profound alterations: (1) The protoplasm disappears and takes no color; (2) the shape is indicated only by a faint line of contour; (3) the nucleus stains faintly; (4) the protoplasm and nucleus disappear, leaving nothing but the flagellum and centrosome, and forming a knob at one end, and (5) the flagellum may be found alone or attached to the centrosome.

Figures 68, 48 to 69, 51, illustrate some of the involution forms given by various authors, and figs. 70, 52 to 59 others which have been observed in our work.

Distribution in the body.—The great majority of writers agree that *Trypanosoma* in an infected animal are found in all the body juices, and are not present at the same time in enormous numbers in one part of the body with but few in another. Animals having many parasites in the blood, when killed show them also in the organs; but if they are not demonstrable by microscopic examination in the former, they are also not found in the latter. The blood of animals suffering from the disease is always infectious by animal inoculation, although there are periods during its course when the parasites can not be found for days by microscopic examination. Plimmer and Bradford, and others state that the lymphatics near the point of inoculation first show the parasite, and that the animal's blood may be infectious for two days before the parasites are found therein.

There are, however, a number of writers who do not accept the general statement given above, but who believe the parasites to be more numerous in certain organs, such as the lymphatics and the bone marrow, than in others. Martini regards the spleen, lymphatics, bone morrow, and to a less extent, the liver and kidneys, as the places for the destruction of *Trypanosoma*.

Elaborate experiments have been performed to show whether or not reproduction occurs in any special organ, but practically without success.

It has repeatedly been shown that a hyperplasia of the lymphatics occurs to a greater extent in an animal inoculated after splenectomy than in one on which this operation has not been performed. Here again we revert to Voges's statement that the whole cycle of the parasite is acted out in the blood; and it would seem that the experiments conducted to determine the place of multiplication in the body tend to support this statement. It is certainly true that the *Trypanosoma* are pretty evenly distributed in the body juices and that similar forms are found in all parts.

It seems to be a very generally accepted opinion that *Trypanosoma* inoculated into the peritoneal cavity undergo a considerable multiplication before entering the circulating blood, and by some this time has been considered as constituting the true period of incubation.

Parasites in the dead body.—*Trypanosoma* live only a short time in the body after death. Within two hours signs of degeneration begin; the parasites shrink, assume irregular shapes, and then disappear. Motile parasites are not found two hours postmortem. Ample work fully demonstrating this important point has been done. In exceptional cases living parasites have been found as late as sixteen hours after

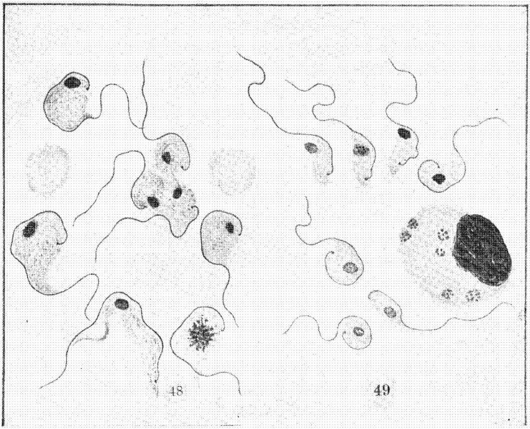

FIG. 68.

Nos. 48-49.—Involution forms of *Tr. equinum*. 48, Involution forms seen in horse twenty-four hours after recovery; 49, involution forms seen in the blood of a horse twenty-four hours after death. Large mononuclear cells containing parts of *Trypanosoma*. (After Sivori & Lecler, 1902, Pl. 6.)

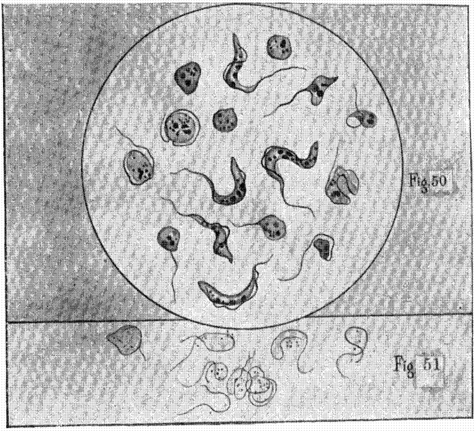

FIG. 69.

Nos. 50-51.—50, *Trypanosoma* of mal de cadéras mixed with serum of chicken and preserved on ice for six days, maintaining their vitality; several have assumed abnormal forms; all have their nuclei reduced to large granulations; stained according to Laveran; 51, *Trypanosoma* in the process of destruction; the free filaments have no centrosomes. (After Lignières, Recueil de Méd. Vét., vol. 10, No. 2, Jan. 30, 1903, Pl. II.)

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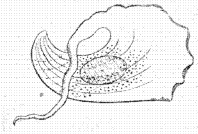
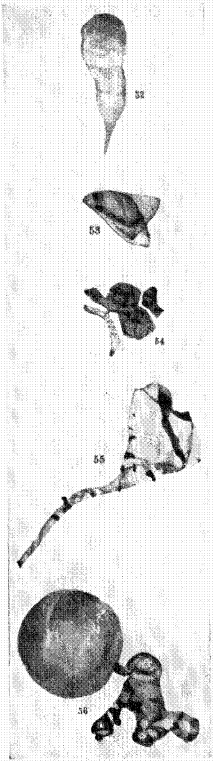


FIG. 71.

Tr. sanguinis Gruby. (After Doflein, 1901, fig. 32).



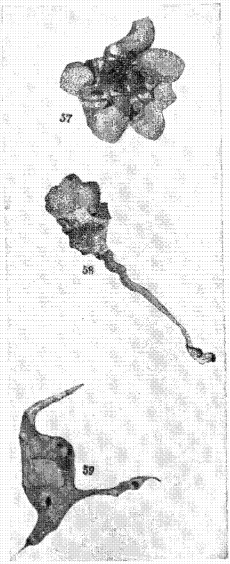


FIG. 70.

Nos. 52-59.—Involution forms of *Tr. evansii* Philipps.

death; but this condition is rare. Our work in this line has consisted in determining the longest time post-mortem during which the blood could be proved infectious by inoculation into susceptible animals. Results are conclusive that this is rarely greater than twenty-four hours. However, in one instance blood has been found to convey the disease forty-eight hours after death.

When an animal in the blood of which *Trypanosoma* are present dies, the parasites are then found in all the organs; and conversely, where none appear in the former, they are also absent in the latter. They are generally distributed, and multiplication forms do not appear in exceptional numbers in any one organ; however, they are usually somewhat more numerous in the spleen, liver, and lymphatic glands than in the bone marrow, and are seldom present in the medullary canal. They are found in the serous fluids and exudates of the joints, but rarely in the urine.

Schilling's results were somewhat exceptional. He says that "*Trypanosoma* were not found in the spleen when positive in the blood, and the peritoneal exudate and bone marrow showed parasites of a budding form;" and again "that *Trypanosoma* might be absent from the fluids and tissues, but were constantly present in the bone marrow." "The number of parasites in the spleen varied greatly, but there was never a great accumulation or multiplication of forms." He draws the conclusion that multiplication of parasites occurs in certain organs while others destroy them.

Trypanosoma outside of the body.—Although *Trypanosoma* in a natural condition are not known outside the body and propagate only to a minimal degree in any known artificial media, yet under favorable conditions they can be kept for a considerable time outside the body, a fact which has been believed to afford certain diagnostic points for different species. Berg kept *Trypanosoma* of fish for six days in blood at 12° C., and Mitrophanow from three to four days in salt solution. Laveran and Mesnil showed that during warm weather living forms of *Tr. lewisii* were found in blood which had been maintained at room temperature for four days. Once, during cold weather, motile parasites added to chicken's or pigeon's blood in a hanging drop were observed after eighteen days. Kept on ice and in blood mixed with physiologic water, they were observed during thirty to fifty-two days, the blood at the end of this time being virulent. They withstood 41° C. very well, but when heated to 50° C. for five minutes were all killed.

Voges states that outside the body *Trypanosoma* of mal de caderas disintegrated rapidly, blood usually being noninfectious after from three to four days. However, he noted one exception where infection occurred with blood which had been kept aseptically for fourteen days. Several writers have tried to attenuate *Trypanosoma* with formalin, heat, and several other means, but entirely without success. The parasites were either all killed so that no infection resulted, or they were as virulent as in control blood. *Tr. equiperdum* (*Elmassiani*) continued motile for forty-eight hours at a temperature of 36° C.

Laveran and Mesnil state that when human serum and blood containing *Trypanosoma* were mixed in equal parts in a hanging drop, the *Trypanosoma* showed feeble action in one-half to one hour, and generally were not motile at the end of two to three hours. Kanthack, Durham, and Blandford determined *Tr. evansii* to be destroyed by complete drying; they also demonstrated four days as the greatest length of time during which they could live in aseptically drawn blood. Laveran and Mesnil, Voges, and others have shown that the blood of an animal infected with *Trypanosoma* was not capable of transmitting the disease after twenty-four hours.

Martini states that the warm stage does not increase the life of *Trypanosoma* in vitro. He noted a bunching of parasites in dead bodies, and considered this a form which they assumed on dying.

Laveran and Mesnil state that the serum of immune deer, mixed in the hanging drop with infected blood, showed no parasiticidal action; and this was found to be true with most other sera. Infectious nagana blood exposed to a temperature of 41° C. for one hour showed deformed and nonmotile parasites, but was still capable of transmitting the disease. Exposure to a temperature of 41° C. and 44° C. for a short time killed the *Trypanosoma* and the blood was no longer infectious.

Many chemical substances quickly destroy the parasites outside the body. Laveran and Mesnil report that they were rapidly killed by the newer silver salts, and that a 1 per cent solution of Toluidin blue attenuated them somewhat, as was shown by the prolonged incubation period. Sivori and Lecler consider the life of the parasite in vitro to be variable, depending upon the conditions produced, but never reaching four days. Schilling noted that *Trypanosoma* were soon destroyed by a 60 per cent solution of bile.

Bruce showed that dried blood was infectious after twenty-four hours in one out of three experiments, with an incubation period of sixteen days. In two cases it was not infectious at the end of forty-eight hours. Aseptically drawn virulent blood was infectious for four days and after seven did not produce the disease.

Laveran and Mesnil state that the movements of *Trypanosoma* are retarded by cooling and accelerated by warming the blood in which they are contained. They were not immediately killed by a temperature of 50° C. to 55° C. below zero. Their experiments were as follows:

Experiment I.—Rat blood with many *Tr. brucei* diluted with potassium citrate solution and kept at 18° C. for one-half hour. One and one-half hours after returning to room temperature it still showed many normal-looking motile *Trypanosoma.* Mice injected in the conjunctiva with this blood died in the usual time with trypanosomiasis.

Experiment II.—Similar dilutions of blood exposed twenty minutes to 15° C. and eight minutes to 25° to 30° C. After two hours warmed blood showed normal-looking motile *Trypanosoma* and was infectious in the usual time for mice.

Experiment III.—Similar solution of blood exposed for one-half hour at 15° C. and five minutes at 50° to 55° C. After two hours the thawed aud warmed blood contained normal-looking and motile *Trypanosoma* and was infectious for mice in the usual time.

Experiment IV.—Same as No. 3, except that the freezing and thawing was repeated. It was still pathogenic for mice, but was slightly slower in its action.

These authors demonstrated that blood infected with *Tr. brucei* heated three hours at 40° C. or one hour at 42° C. was still virulent. Blood infected with *Tr. brucei* heated twenty minutes at 40° C. to 44° C. killed nearly all the *Trypanosoma,* and when heated to 44° C. to 45° C. all the parasites were quickly destroyed.

Blood taken aseptically and mixed with citrate solution at room temperature, according to Laveran and Mesnil, was virulent for three days, and *Trypanosoma* lived longer in a mixture of blood and serum than in blood alone. In the defibrinated blood of a rat mixed with the serum of the host motile *Trypanosoma* were still observed after three days.

Human serum and that of refractory animals was not considered less adapted to the preservation of *Trypanosoma* than that of more susceptible animals. *Tr. lewisii* lived longer on ice than at room temperature, but this was not true of *Tr. brucei.* Blood containing *Tr. brucei,* after being kept on ice for three to five days, was often noninfectious, though it still contained slightly motile *Trypanosoma.* Involution forms quickly appeared in blood kept on ice, their morphology differing in no respect from that of the involution forms produced by other causes.

We have experimented extensively with the object of determining the length of life in vitro of the *Trypanosoma* with which we have been able to work, and on the whole have obtained results similar to those arrived at by most recent writers on other *Trypanosoma.*

Our experiments made to determine the action of heat and cold on parasites confirm, in the main, the conclusions drawn by Laveran and Mesnil, including the differentiation of *Tr. lewisii* by its ability to live longer than *Tr. evansii* in the ice box. We failed to find any constancy in the agglutinations these authors describe. They did occasionally occur, following exposure to conditions especially adverse to life; but they were not constant and also took place in the hanging drop. We can not attach to this phenomenon the importance given it by some authors.

Several specific sera mixed in the hanging drop in equal parts with blood rich in *Trypanosoma* gave no appreciable results, with the possible exception of the mixtures containing antiplague and antirinderpest sera. The *Trypanosoma* were usually nonmotile in the plague serum at the end of forty minutes, and in the rinderpest serum sometimes as early as thirty minutes. In two out of five experiments made with the latter the blood was noninfectious for rats at the end of one hour. In most of the experiments made with serum the parasites lived as long as in the control drop, and in some instances much longer.

A 1-500 solution of quinine mixed in equal parts with blood containing *Trypanosoma* arrested the motility of the parasites in from five to ten minutes. With a 1-1,000 solution of methylene blue the *Trypanosoma* lost their motility from five to twenty minutes earlier than in the control. They are less affected by solutions of alcohol, glycerin, or ether.

No perceptible action was produced on the *Trypanosoma* by mixing the infected blood with equal parts of the following substances: A 1-1,000 solution of acetozone; 1-1,000 solutions of the soluble eosins, alcohol, potassium acetate, potassium chlorate, potassium cyanide, salt solution, picric acid, oxalic acid, and the chlorides of magnesium, calcium, and barium. Indeed, in many of these solutions the parasites remained active longer than in control.

The *Trypanosoma* were quickly destroyed by mixing infected blood in the hanging drop with equal parts of the following substances: A 1–1,000 solution of arsenious acid, a 1–1,000 solution of turpentine, a 1–1,000 solution of corrosive sublimate, a 1–500 solution of chloral hydrate, a 1–500 solution of carbolic acid, a 1–500 solution of formalin, a 1–1,000 solution of potassium permanganate, and a 1–200 solution of quinine.

CLASSIFICATION.

Authors differ considerably in the classification of this family of the *Protozoa*.

Doflein, 1901, divides the genus *Tr. Gruby* into three subgenera, as follows:

1. Major flagellum present 2
   Major flagellum absent, or very short and thick .... *Trypanosoma.*
2. Undulating membrane continued posteriorly in a flagellum so that 2 flagella are present .... *Trypanomonas.*
   Posterior flagellum absent, undulating membrane ending on or before end of body .... *Herpetosoma.*

Leveran and Mesnil, 1901, have shown Doflein's *Trypanomonas* to be a distinct genus and have given it the name *Trypanoplasma*, with *Trypanoplasma borrelii* as a type species.

Salmon and Stiles criticise Doflein's classification and divide the family *Trypanosomidæ* into two genera—*Trypanosoma* and *Trypanoplasma*. With a few minor changes, this classification is adopted tentatively in this report. However, as will be seen by following the discussions, we are strongly of the opinion that at least two of the parasites of mammals, and probably others, are identical with *Tr. evansii*, and in reality the names of these should fall as synonyms of *Tr. evansii*.

PROTOZOA, class Mastigophora, subclass *Flagellata*, order Monadida, family Trypanosomidæ, genus *Trypanosoma* Gruby.

Trypanosoma: One flagellum present extending from the centrosome along the undulating membrane and becoming free at the anterior extremity.

Trypanoplasma: Two flagella, one extending anteriorly and the other posteriorly.

Trypanosoma rotatorium Mayer, 1843; L. & M., 1901.

Synonyms: Amœba rotatoria Mayer, 1843, July; *Paramoecium loricatum* Mayer, 1843, July; *Paramoecium costatum* Mayer, 1843, July; *Trypanosoma sanguinis* Gruby, 1843, November; *Globularia radiata sanguinis* Wedl, 1850; *Undulina ranarum* Lankester, 1871; *Herpetomonas* Kent, 1880; *Paramecioides costatum* Grassi, 1881; *Paramecioides costatus* Grassi, 1883; "*Trypanosoma sanguinis* Gruby" of Lanessan, 1882; "*Gloubularia radiata* Wedl, 1849" of R. Blanchard, 1885; *Haemetomonas* Mitraphanow, 1883; *Trypanomonas ranarum* Danilewsky, 1885; "*Spirochæte* of Steele," 1885; "*Hemotomonas*" of Blanchard, 1888; "*Trichomonas sanguinis*" of Crookshank, 1886; *Trypanosoma renarum* (misprint for *ranarum*) 1889; *Trypanosoma costatum* Danilewsky, 1889; *Trypanosoma costatum ranarum* Danilewsky, 1889; *Trichomonas ranarum* (Lankester) Danilewsky, 1889; *Trichomonas batrachorum* Danilewsky, 1889; "*Trypanosomes* Gruby" of Laveran, 1895; "*Trypanosomum*" Chauvrat, 1896; "*Trypanosome* Gruby" of Buffard and Schneider, 1900; "*Paramoecium loricatum* Mayer" and "*Paramoecioides costatus* Grassi" of Laveran and Mesnil, 1901.

Trypanosoma avium Danilewsky, 1885, of birds.

Synonyms: Trypanosoma avium Danilewsky, 1885; *Trypanosoma fusiforme* Danilewsky, 1889; *Trypanosoma minus* Danilewsky, 1889; *Trypanosoma majus* Danilewsky, 1889; *Trypanosoma sanguinis avium* Danilewsky, 1889; *Trypanosoma costatum* Danilewsky, 1889; *Trypanosoma major* Danilewsky, 1889.

?Trypanosoma eberthii Kent, 1880, of fowls (intestine).

Synonyms: Trypanosoma eberthi Kent, 1880; "*Trypanosoma eberthi*" of Lanessan, 1882; *?Cercomonas gallinarum* Davaine, 1877; *?Cercomonas gallinae* Rivolta, 1880; *Trypanosoma eberthi* of Lecerlq, 1890; *Trychomonas columbarum* Kruse, 1896.

Trypanosoma cobitis Mitraphanow, 1883, of mudfish.

Synonyms: Hæmatomonas cobitis Mitraphanow, 1883; *Trichomonas cobitis* (Mitraphanow) Crookshank, 1886; *Trypanosoma piscium* Danilewsky, 1885; *Trypanosoma* (*Herpetosoma*) *cobitis* (Mitraphanow) of Doflein, 1901; *Hæmatomonas cobitidis* Luehe, 1902.

Trypanosoma carassii Mitraphanow, 1883, of fish.

Synonyms: Hæmatomonas carassii Mitraphanow, 1883; *Trichomonas carassii* (Mitraphanow) Crookshank, 1886; *Trypanosoma piscium* Danilewsky, 1889; *Trypanosoma fusiforme* Danilewsky, 1889; *Trypanosoma* (*Herpetosoma*) *carassii* (Mitraphanow) 1883, Doflein, 1901.

Trypanosoma soleae Laveran and Mesnil, 1901, of soles.

Trypanosoma balbianii Certes, 1882, of oysters.

Synonyms: Trypanosoma balbiani Certes, 1882; *Trypanosoma balbianii* (Certes) Balbiani, 1888; "*Trypanosoma balbianii*" of Danilewsky, 1889.

Trypanoplasma danilewskyi Labbe, 1891.

Synonyms: Trypanomonas danilevskyi Labbé, 1891; *Trypanosoma* (*Trypanomonas*) *danilevskyi* (Labbé) Doflein, 1901.

Trypanoplasma borrelii Laveran and Mesnil, 1901.

Trypanosoma lewisii Kent, 1880, of rats.

Synonyms: Herpetomonas lewisi Kent, 1880; "*Herpemonas lewisi* Kent," 1880; *Trichomonas lewisi* (Kent) Crookshank, 1886; *Herpetomonas lewisii* Danilewsky, 1889; *Trypanomonas murium* Danilewsky, 1889; *Trypanomonas lewisi* (Kent) Labbé, 1891; *Trypanosoma lewisi* Kent; *Trypanosoma* Kanthack, Durham and Blandford, 1898; *Trypanosoma rattorum* Boerner, 1901; *Trypanosoma* (*Herpetosoma*) *lewisi* (Kent) Doflein, 1901.

Trypanosoma evansi; Steel, 1885, of surra.

Synonyms: (Genus not named) ferox Evans, 1881 (not entitled to priority); *Spirocheate evansi* Steel (not accessible); "*Spirochæta evansi* Steel," 1885, of Crookshank, 1886; *Hæmatomonas evansi* (Steel) Crookshank, 1886; *Trichomonas evansi* (Steel) Crookshank, 1886; "*Homotomonas evansis*," Blanchard, 1888; "*Trichomonas sanguinis* Crookshank" of Balbiani, 1888; "*Spirochetæ evansii*" of Nariman and Vaz, 1893; "*Spirochetæ evansii* Steel" of Laveran, 1895; "*Trypanosomum evansi* (Steel) Chauvrat," 1896; *Trypanosoma evansi* (Steel) Pease, 1897; *Trypanosoma evansii* Pease, 1897; *Herpetomonas lewisii* Steel, of Danilewsky, 1889; *Trypanosoma* (*Herpetosoma*) *evansi* (Steel) Doflein, 1901; "*Trichomonas sanguinis evansi* Crookshank" of Doflein, 1901.

Trypanosoma brucei Plimmer and Bradford, 1899, of tsétsé disease.

Synonyms: Trypanosoma brucii Plimmer and Bradford, 1899; "*Trypanosoma brucei*" of Schneider and Buffard, 1900; *Trypanosoma* (*Herpetosoma*) *brucei* Plimmer and Bradford, of Doflein, 1901; *Herpetomonas brucei* (Plimmer and Bradford) Laveran and Mesnil, 1901.

Trypanosoma nepbeui, of man.

Synonyms: Trypanosoma gambiense Dutton, 1902; *Trypanosoma fordii* Maxwell, Adams, 1903.

Trypanosoma rougetii Laveran and Mesnil, of dourine.

Synonyms: Trypanosoma equiperdum Doflein, 1901, July 1; "*Tryanosoma*" (*Herpetosoma*) *equiperdum* Doflein, 1901; *Trypanosoma* (*Hæmatomonas*) *equiperdum* Doflein of Luehe, 1902.

Trypanosoma equinum Voges, 1901, of mal de caderas.

Synonyms: Trypanosoma equinum Voges, 1901; *Trypanosoma equinum* Voges of Railliet, 1901; *Trypanosoma elmassiani*, 1902.

Trypanosoma therrellii Laveran and Mesnil, 1901, of cattle.

Trypanosoma transvaaliense Thuiler, Laveran and Mesnil, 1902, of cattle.

Trypanosoma rotatorium MAYER, 1843.

The length of this parasite, including the flagellum (which is 10 to 12 microns long), is usually given as being about 40 to 80 microns, while the breadth is 5 to 10 microns. Doflein says it has a broader body and undulating membrane than most of the other *Trypanosoma*. It has a granular protoplasm and a large, clear nucleus. One end is somewhat blunt and the other is provided with a short flagellum.

Salmon and Stiles, in their specific diagnosis of this parasite, after giving the dimensions, state that "the body is compressed, semilunate, twisted; the convex border membranous and undulating; the posterior extremity of the body portion pointed and curved inward, the opposite one produced into a long tag or tail-like appendage, which almost equals in length the remainder of the body; surface of the body coarsely striate longitudinally; endoplasm or parenchyma slightly granular; endoplast ovate, central."

Habitat.—Blood of frogs (*Rana esculenta*, *Rana temporaria*, and *Rana arborea*).

According to Doflein, the mode of transmission is not fully determined, and this statement is confirmed by Laveran and Mesnil. There may be more than one species of this parasite, but so much of the work regarding it is unsatisfactory that for the present it seems advisable to consider it a single species. It apparently has no special pathologic significance, and for that reason is of but little importance in this paper.

We have examined the blood of a large number of several varieties of frogs here, but have failed to find this or any other *Trypanosoma*.

Trypanosoma avium Danilewsky, 1885.

Salmon and Stiles give as its specific diagnosis: "*Trypanosoma* 18 to 60 microns long; body cylindrical, compact, fusiform, and homogeneous; anterior extremity gradually attenuate, and continuing directly into a long or short flagellum; flagellum

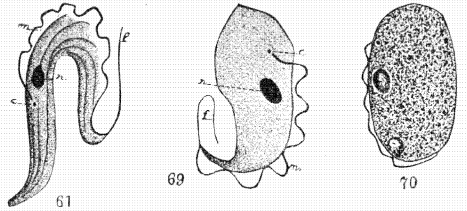
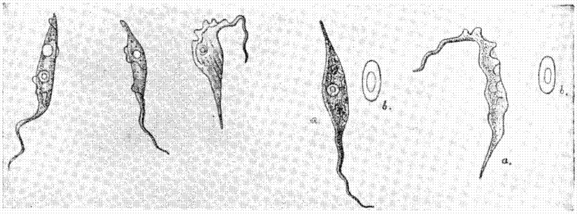


FIG. 72.

Nos. 61, 69, 70.—Showing different forms of *Tr. rotatorium*. *f*, Flagellum; *m*, undulating membrane; *n*, nucleus; *c*, centrosome. (After Laveran and Mesnil, 1901, figs. 1–3.)



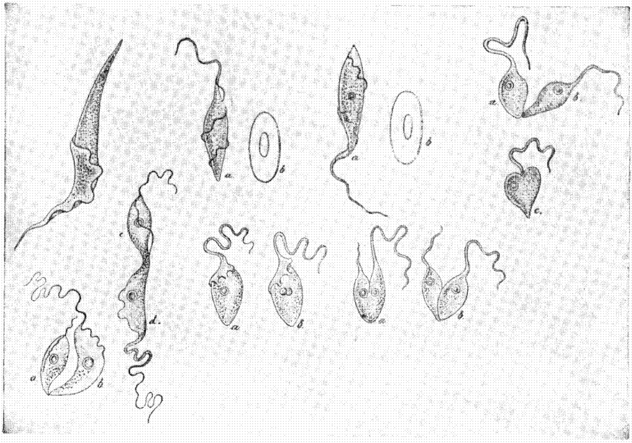


FIG. 73.

Various forms of *Trypanosoma* of birds. (After Salmon and Stiles, 1902, figs. 53–64.)

M10U

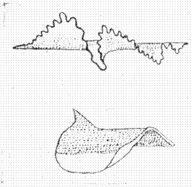


FIG. 74.

Tr. eberthii. (After Doflein, 1901, fig. 33.)

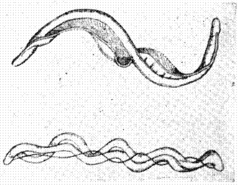


FIG. 75

Tr. balbianii Certes. (After Lustrac).

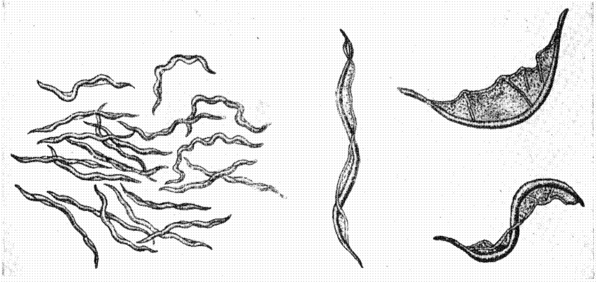


FIG. 76.

Tr. balbianii Certes. (After Salmon and Stiles, 1902, figs. 76-79.)

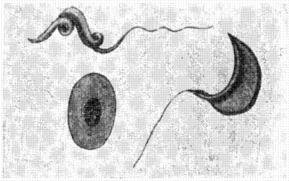


FIG. 77.

Tr. cobitis Mitrophanow. (After Mitrophanow.)

MdU

intimately united with the undulating membrane, which extends from the flagellum to the posterior extremity; nucleus spherical in equator or anterior half of body."

There have been found in literature several references reporting *Trypanosoma* in birds, but most of the descriptions are inadequate. We have examined a large number of birds of several varieties in the Philippine Islands, but we have failed to find *Trypanosoma* in their blood, and have been entirely unable to infect them with the *Trypanosoma* with which we have worked.

?,*Trypanosoma eberthii Kent, 1880.*

Salmon and Stiles and others doubt the correctness of the classification of this species; Doflein believes that two or three species have been confused in its description.

It is described by Doflein as half-moon in shape, the concave side being the body of the parasite, and the convex the undulating membrane, which has numerous small folds. The protoplasm is homogeneous and contains a nucleus. One end of the body is blunt, and the other is tapering and continues into a short, motionless projection. Kent says that the membranous border is often spirally convoluted around the thicker central portion, the entire body under such conditions assuming a auger-like aspect.

Habitat.—Glands of Lieberkühn, cecum and ileum of chickens, doves (?), ducks, and geese. Rivolta and Pfeiffer, according to Doflein, found this organism, or a similar one, in poultry diphtheria.

In the few chickens, pigeons, and small birds which we have examined in Manila, these parasites have not been found. It seems more than likely that some of the *Trichimonidæ* have been mistaken for *Trypanosoma*, as it is doubtful that so strict a blood parasite would be found in the intestinal canal of birds.

Trypanosoma balbianii Certes, 1889.

Doflein gives the length of this parasite as 50 to 180 microns and the breadth as 1 to 3 microns. Salmon and Stiles give the length as 50 to 18 microns and the breadth as 1 to 30. It is described by Doflein as an elongated parasite with slender body and slender undulating membrane. Certes, Lustrac, and others have observed longitudinal division, which Lustrac says begins in the undulating membrane. Laveran and Mesnil do not consider this parasite a member of the family *Trypanosomidæ.*

Habitat.—Intestines of oysters (*Ostra edulis, Ostra angulata, Grypha angulata*) and mussels (*Tapes decussata, Tapes pallustra*).

Pathogenesis.—Not known.

Neither this nor any other *Trypanosoma* has been observed by us in the examination of a large number of oysters of the Philippine Islands.

Trypanosoma cobitis Mitrophanow, 1883.

A very active and motile *Trypanosoma,* 30 to 40 microns long by 1 to 1.5 microns broad. Doflein says that one end tapers abruptly and the other gradually, ending in a flagellum 10 to 15 microns in length. The undulating membrane is distinct in prepared specimens. The protoplasm is homogeneous, except, according to Doflein, in multiplication and degenerating forms, where it may be granular.

Habitat.—Blood of mudfish (*Cobitis fossilis*).

Pathogenesis.—Described experiments have failed to convey the infection from fish to fish, or from fish to animals, by inoculation.

Trypanosoma carassii Mitrophanow, 1883.

Doflein says that it is very similar to *Tr. cobitis,* but more flattened; that the undulating membrane is better developed and the body more uniformly pointed at both ends and larger than that of *Tr. cobitis.*

Habitat.—Blood of fish (*Carassius vulgaris*). Doflein observed it or very similar parasite in the tench (*Tinca vulgaris*).

Pathogenesis.—Not known. The *Trypanosoma* which Doflein observed were found in sick fish.

The fish of the Philippine Islands are apparently free from this *Trypanosoma.*

Trypanosoma remakii Laveran and Mesnil, 1901.

Trypanosoma 28 to 30 microns in length and very slender. Two sizes and possibly two varieties. Very closely resembles *Tr. lewisii,* actively motile, with undulating membrane, both ends tapering with a long flagellum at the anterior end, protoplasm finely granular. The larger forms measure 45 microns in length and 2 to 2.5 microns in breadth, and stain somewhat better than the small variety.

Habitat.—Blood of pike (*Esox lucius*).

Pathogenesis.—Not infectious by inoculation.

We have not succeeded in finding *Trypanosoma* in the blood of fish in the Philippine Islands, although several varieties of both salt and fresh water fish have been examined.

Trypanosoma soleæ Laveran and Mesnil, 1901.

A *Trypanosoma* resembling *Tr. lewisii* 40 microns in length, very actively motile, structure in general like that of the other members of the family, posterior end not so sharp, nucleus oval, centrosome present and undulating membrane well developed.

Habitat.—Blood of sole (*Solea vulgaris*) of France.

Pathogenesis.—Laveran and Mesnil did not succeed in infecting other animals with this *Trypanosoma.*

Trypanoplasma borrelii Laveran and Mesnil, 1901.

Laveran and Mesnil describe this parasite as a *Trypanoplasma,* with two flagella both extending from the centrosome and one going to each extremity, the anterior one bordering a well-defined undulating membrane and extending into a free flagellum 15 microns in length. The total length of the parasite with flagella is about 50 microns and the breadth 3 to 4 microns. One end is more pointed than the other and very motile. This parasite changes its form, sometimes resembling an ameba. Two chromatin masses lie close together near the junction of the posterior and anterior parts of the body, one of these masses resembling a nucleus and the other a centrosome.

It is to be noted here that Labbé (1891) had already seen a *Trypanoplasma* with two flagella in the blood of leeches, and that Künstler (1898) had mentioned a similar organism found in the blood of a guinea pig. Figure 81–89 is Labbé's illustration of the parasite observed by him in leeches in 1891.

Habitat.—Found by Laveran and Mensil in the blood of the redeye (*Leuciscus erythropthalmus*) of France.

Pathogenesis.—Not infectious by inoculation.

Trypanosoma lewisii Kent, 1880.

Gros in 1845, Chaussat in 1850, and later other authors found remarkable parasites, which for a long time were the cause of controversy, in the blood of rats and hamsters. While some considered them as amebæ, flagellates, etc., there were others who did not recognize them as independent organisms, but as spermatazoa, or as Siebold even considered them small patches that somehow had been torn loose from the walls of the circulatory and lymphatic systems.

After a long pause interest in this organism was again aroused, and a large number of articles dealt with the subject, without mentioning or recognizing the earlier works. Lewis (1879 and 1880), Wittich (1881), Robert Koch (1881), Crookshank (1887), published several treatises on *Tr. lewisii,* to which Kent in 1882 gave its name; but he placed it in the genus *Herpetomonas,* which according to diagnosis accepted at present possesses no undulating membrane. With less exactness, Labbé, Danilewsky, and Mitrophanow also dealt with the species, while all investigators of surra likewise refer to it. Interest was awakened through the investigations of surra and tsetse-fly disease, and has recently been increased by the observations of Koch, Rouget, and others, but especially by the important works of Rabinowitch and Kempner, Wasielewski and Senn, and Laveran and Mesnil which explain the methods of multiplication and widen our knowledge considerably.

Rabinowitch and Kempner, as well as Wasielewski and Senn, have studied multiplication forms with a considerable degree of thoroughness. Their investigations agree on essential points. According to them there are three kinds of multiplication; two forms of division and one form of multiplication through segmentation, a division into numerous rosette-shaped sprouts lying side by side.

Whether conjugation takes place is yet unknown, but to Doflein it appeared that such a process precedes the multiplication by division into sprouts. Some pictures of Rabinowitch and Kempner point to such a course. This, however, is still very problematical, especially since the life history of *Trypanosoma* is not fully understood.

Senn, for example, considers the ordinary division as budding, since, according to his statement, the mother parasite is always larger than the daughters produced by her. The individuals are seen rapidly to increase, especially after a new infection.

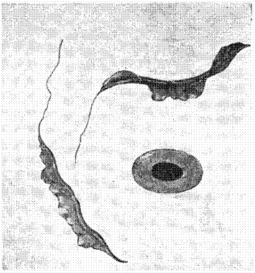
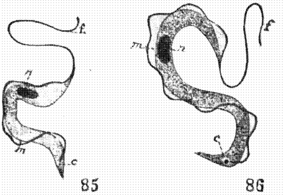


FIG. 78.

Tr. carassii Mitrophanow. (After Mitrophanow.)



FIGS. 79, 80.

Nos. 85–86. 85, *Tr. remakii parvum*; 86, *Tr. remakii magnum*; *f*, flagellum; *m*, undulating membrane; *c*, centrosome; *n*, nucleus. (After Laveran and Mesnil, 1901, fig. 3.)

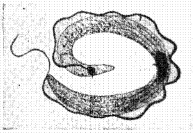


FIG. 81.

Tr. solex. *f*, flagellum; *m*, undulating membrane; *c*, centrosome. (After Laveran and Mesnil, 1901, fig. 3.

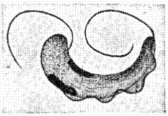


FIG. 82.

Trypanoplasma borellii. (After Laveran and Mesnil, 1901, fig. 4.)

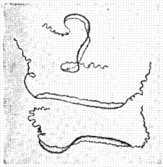


FIG. 83.

Trypanoplasma danilewskyi Labbé. (After Salmon and Stiles, 1902, fig. 83.)

UofM

M10U

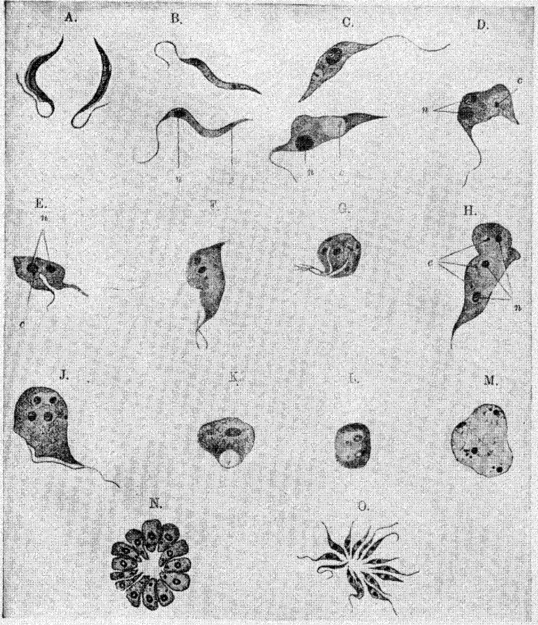


FIG. 90.

Tr. lewisii Kent. A, adult living parasites; B, adult stained parasites; C–F, stages of longitudinal division; G, multiple longitudinal division; H, beginning multiple transverse division; I–M, other forms of division; N–O, rosette forms of division; *n*, nucleus; *c*, centrosome. (After Rabinowitsch and Kempner.)

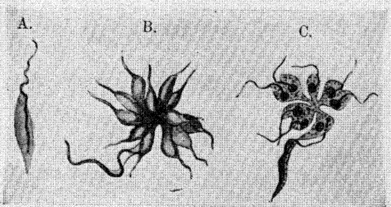


FIG. 91.

Tr. lewisii Kent. A, adult parasite; B, multiplication forms in fresh specimen; C, multiplication forms in stained specimen. (After Wasielewsky and Senn.)

M7cU

impetuously dividing themselves. The divisions are often multiple, and the mother is seen to separate into two, three, four, and even eighteen daughters. Senn considers the rosette formation to be the result of a division into several individuals, and not as a special form of multiplication; but since the complete life cycle of the species has not been positively determined, this is also a mere theory.

In any case separation into two parts is the typical form of longitudinal division, and the apparent deviations in prepared specimens are explained by the delicacy of the protoplasm, which on being killed assumes the most varied forms. As yet resting forms have not been observed.

Habitat.—This species lives in the blood of rats (*Mus rattus*, *Mus decumanus*, *Mus refuscens*) and in that of the hamster (*Cricetus arvalis*). Thus far it has been observed in Europe (Germany, England, France, Italy, and Russia), in Asia (India, Japan, and the Philippines), and in Africa (Dutch East Africa and Algiers).

Pathogenesis.—The parasite is found in the blood of animals attacked by the disease. In the case of rats it sometimes produces sickness and death, but it is generally found in apparently healthy animals. Wild rats are often found infected with it, but in tame ones, especially in the white variety, its occurrence is rare, although these as well as white mice are susceptible to the disease. In many instances 25 to 29 per cent, but in others a much smaller percentage of wild rats has been found infected. Under certain conditions epidemics seem to break out.

Whether the *Trypanosoma* which appear in hamsters and those found in rats are identical can not yet be stated positively.

This parasite is very common in rats in numerous places both in the trypanosomatic zone and in countries which have apparently always been free from the disease in domestic animals. For the purposes of study it is one of the most easily obtainable, and because of its nonpathogenic significance and its very close relation to the more virulent forms is one of the most important of the genus. The history and synonyms recognized by leading authors have been given above.

Salmon and Stiles give as the specific diagnosis:

"Eight to 10 microns long by 2 to 3 microns broad; 24 to 25 microns long by 1.4 microns broad (Laveran and Mesnil, 1901); a very refringent granule (near centrosome) in place of which a clear vacuole is seen in stained preparations. 'Animalcules exceedingly minute, attenuate and vermicular under normal conditions, but highly polymorphic and capable of assuming a variety of contours; flagellum single, terminal, two or three times the length of the extended body; no contractile vesicle * * * as yet detected.'"

Doflein's description translated reads as follows:

"The *Trypanosoma* of rats is lance-shaped and reveals a very finely granular protoplasm, around which a thin hyaline but clearly visible entoplasm lies. From the latter spring the flagellum and the undulating membrane. The flagellum is almost as long as the body itself, and springs from the posterior end of the parasite with a central nucleus-like structure considered as its origin, and then continues as a thickening of the edge of the undulating membrane, first becoming free at the anterior end of the parasite and wriggling about in the medium surrounding it. In the anterior part of the parasite is found the somewhat large nucleus, staining deeply and filled with a dense chromatin network. A contractile vacuole has not been seen. The length of *Tr. lewisii* varies between 8 and 10 microns and the breadth between 2 and 3 microns."

As is true of other parasites, *Tr. lewisii* undoubtedly shows variations in size. Individuals are found not measuring more than 15 to 20 microns in length by 1 to 2 microns in breadth. On the other hand, specimens are seen which may be fully 30 microns long and 3.5 microns broad. The average measurements of adult parasites observed in Manila rats, obtained from hundreds of specimens, are 25 microns long by 2.5 microns broad.

On the whole the motility of this parasite in the hanging drop is probably greater than that of any other *Trypanosoma*. The active darting motion observed is not characteristic of all specimens, and we have been unable to determine the responsibility of outside influences for these variations.

In addition to *Tr. lewisii*, Manila rats certainly harbor *Tr. evansii*, and we have not yet satisfied ourselves that there is not a third variety in some of them. This makes observations of *Tr. lewisii* based upon the examination of the *Trypanosoma* found in rats more difficult, and in the past has probably been responsible for the lack of harmony in results obtained.

Numerous comparisons of diagnoses made of rat *Trypanosoma* by morphological characteristics, and by those determined by animal experiments with the same organisms, have fully convinced us of the futility, in many cases, of depending upon microscopic data for the diagnosis of *Tr. lewisii* or of other *Trypanosoma*.

The most trustworthy and important diagnostic point for this parasite besides the animal test is the fact already brought out by others, particularly by Laveran and Mesnil, that it lives so long in the ice box, where in solutions of blood in potassium citrate *Tr. lewisii* retain their activity for days, and always longer than *Tr. evansii*, which on various occasions have been tested side by side with them. They not only retain their activity longer, but also remain infectious for rats for a much greater length of time.

This is not true, however, when compared with the possible third variety of rat *Trypanosoma* mentioned above. These are excessively motile, remaining so for a long time in the ice box, where they maintain their infectiousness. The supposition that these *Trypanosoma* belong to a separate species has been gradually evolved from experimental data. There have been times when we have felt confident we were working with *Tr. lewisii*, only to find the parasites infectious for dogs, monkeys, etc., after two or three days in the ice box. At present this point has not been satisfactorily determined and must be left to a future discussion.

Of this we are sure—that *Trypanosoma* corresponding in every respect to the descriptions given of *Tr. lewisii*, including their noninfectiousness for other animals, may be found in the blood of Manila rats. In addition to these, *Trypanosoma* correct in every essential for *Tr. evansii* occur in these rodents, as well as parasites which microscopically resemble *Tr. lewisii*, but are infectious for other animals, producing disease and death.

Trypanosoma evansii Steel, 1885.

A motile *Trypanosoma*, 20 to 30 microns in length by 1 to 2 microns in breadth, somewhat blunt at the posterior end and gradually tapering at the anterior end. The undulating membrane is well defined, beginning at or near a small body in the posterior portion of the parasite and extending forward as a free flagellum. This *Trypanosoma* is provided with a nucleus and a granular protoplasm.

We have classified the parasite causing *trypanosomiasis* in the Philippine Islands as *Tr. evansii*. It is the name adopted for the original organism causing the disease in domestic animals; and the one in the Philippine Islands answers the descriptions of this *Trypanosoma* as well as do some of the parasites later to be discussed.

It is a *Trypanosoma* from 20 to 30 microns long by 1 to 3.5 or 4 broad, including the flagellum. The gradually tapering anterior end is provided with a long flagellum, which in the living parasite has a very active motion and is a free continuation of the thickened border of the undulating membrane. It extends backward along this membrane to its end, about one-third to three-fourths the length of the parasite, and terminates at or near the centrosome (micronucleus). The undulating membrane extends from the posterior portion of the parasite along one border to the anterior, where it gradually tapers into the free flagellum. This membrane, active in the living parasite, in fixed specimens is found to be more or less folded, giving it a ruffled or fluted appearance. It is usually homogeneous, but sometimes contains granular matter apparently identical with that found in other parts of the parasite. The posterior end of the parasite is more or less blunt. In the living state this part is undoubtedly contractile, a fact which accounts for the varying degrees of bluntness seen in fixed specimens. Too much importance has been attached to the shape of this extremity, which in the parasites observed by us varies too much to be very significant as a diagnostic point.

The *protoplasm* of the parasite alters considerably with conditions, one of which is probably the age of the organism. In some it is almost homogeneous as viewed with a Zeiss 1/12 objective ocular 4. It is usually granular, especially in the anterior portion, the granules being either small or large, but more often of the two kinds. A number of the larger chromatin granules, which may measure as much as 1 micron, are often seen near the centrosome, again in the anterior portion, and sometimes well up into the flagellum. We have observed them a few times in the undulating membrane.

The nucleus is situated somewhat anteriorly to the center and is oval or round and of good size. A nucleolus is not usually observed. The nucleus takes a characteristic stain and is homogeneous or slightly irregular in structure; but we have been unable to bring out the beautiful effects of karyokinetic division illustrated by some authors.

The centrosome is situated in the posterior portion, its distance from the posterior end varying from one-fourth to one-third the length of the parasite, depending no doubt upon the degree of contraction of this part at the time of fixing. It is chromatic and within small limits varies in size. It is intimately associated with the beginning of the undulating membrane and flagellum, and while difficult to demonstrate satisfactorily is probably the head of the flagellum.

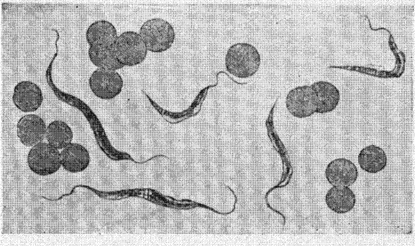
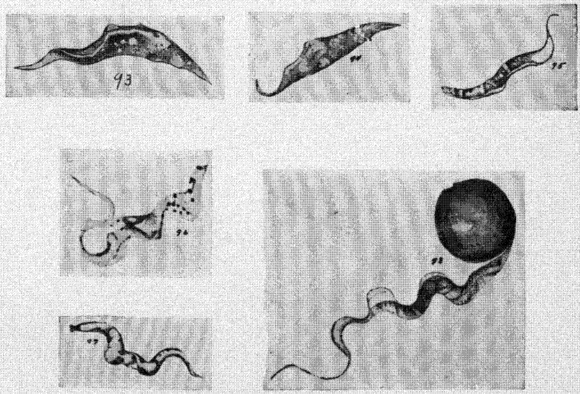


FIG. 92.



FIGS. 93-98.

In fresh specimens the parasite has an eel-like motion, owing to the vibration of the undulating membrane and flagellum, and to a less extent to the action of the entire parasite. The actual motility varies in some specimens, and, while it is generally not great, it may be quite extensive. These variations are difficult to explain, the more so since they occur in specimens prepared from the same animal at different times. For the study of structure, fixation and staining are necessary. The various methods which have been published for showing the motion of the living parasite in such a way as to reveal the structure are unsatisfactory.

Habitat.—The habitat of this *Trypanosoma* has already been given, but we wish to add Manila rats to the list. This fact merits especial emphasis in the consideration of measures for the control of the incurable malady caused by the parasite.

Pathogenesis.—It is pathogenic for nearly all animals, as will be seen when the discussion of susceptible animals is reached.

Trypanosoma brucei Plimmer and Bradford, 1899.

Laveran and Mesnil describe it as a *Trypanosoma* 26 to 27 microns long by 1 to 1½ microns broad. In horses and asses it may reach 26 to 30 microns in length. The size, however, varies but little. It is a motile, worm-like organism, with an undulating membrane extending into a long flagellum at the anterior end. The posterior end is variable—round, tapering, or cone-shaped. The motility is not great. The structure is not well-marked in fresh specimens, but in stained ones it closely resembles that of *Tr. lewisii.* It contains large, deeply-staining granules, especially in the anterior end. The nucleus near the middle of the body is elongated and contains deeply-staining granules. The centrosome is near the posterior end, and is a round corpuscle staining more intensely than the nucleus and often surrounded by a clear zone in stained specimens. The flagellum, free in the anterior end, continues along the undulating membrane and stops near the centrosome, appearing, however, to be separated from it by the clear zone above mentioned. In involution forms flagella often appear to have direct connection.

Bruce says that this parasite as found in the dog is thicker, shorter, and the posterior end more rounded than in other animals. In the horse, the dimensions are nearly double, with the posterior end tapering.

Plimmer and Bradford consider the parasite to vary in size and length with the period of the disease and the species of the animal, being the largest in the rat at the time of death.

Salmon and Stiles give as the specific diagnosis of this *Trypanosoma:*

"Twenty-five to thirty microns long, 1. 5 to 2. 5 microns broad. As compared with *Tr. lewisii*, the posterior extremity of *Tr. brucei* is not so sharp, the undulating membrane is broader and more plicate, the protoplasm colors more easily and more deeply, and the movements are less active. The protoplasm contains granules, which accumulate principally in the anterior half, some of which are as large as the centrosome, and they color the same as the centrosome; centrosome divides before the nucleus."

Habitat—It is found in the blood of several species of domestic as well as wild animals. This point is more fully discussed in the chapter devoted to this subject.

Pathogenesis—It is infectious upon inoculation for nearly all animals.

Trypanosoma rougetii; Laveran & Mesnil, 1901.
Trypanosoma equiperdum Doflein, 1901.

Rouget describes this parasite as a motile, worm-like *Trypanosoma* 18 to 26 microns long and 2 to 2. 5 microns broad, with an undulating membrane and a long anterior flagellum. The posterior end is tapering or blunt and contains a small shining globule which does not stain. The protoplasm is granular. He considers it identical with other *Trypanosoma* of domestic animals.

Nocard, who worked with this parasite, considers it and the disease produced by it identical with other *Trypanosoma* and trypanosomatic infections.

Buffard and Schneider maintain a close relationship between this parasite and the others, but they are not sure of their identity.

Habitat.—Blood and lesions of horses and asses suffering from dourine.

Pathogenesis.—Naturally infected animals are horses and asses. Infection may be transferred by inoculation to dogs, rabbits, white mice, and several other animals.

Trypanosoma nepveui.

Whether or not this a distinct species is hardly determinable from the descriptions thus far given, but the work of those having cases of trypanosomiasis in man under observation will probably settle this point. All parasites of human trypanosomiasis are included tentatively in this species for convenience.

Nepveu first described a *Trypanosoma* in human blood as follows:

"This *Trypanosoma* presents all the characteristics of the genus. It has a homogeneous, colorless membrane, one border of which is thinner than the other, and hyaline, with characteristic undulating movements. This membrane bears a nucleus and a fine flagellum, situated anteriorly, the undulations of which follow in rapid succession.

* * * * * * *

"In conclusion, *Trypanosoma* must be classed among the parasites of human blood. I am unable at present to give a more complete description of this variety, and therefore refrain from giving it a special name. It will therefore be best first to establish the similarities and differences between this parasite and the congeneric parasites of animals and also to complete the observations on its morphology and life history."

Dutton, who has found a *Trypanosoma* in Forbe's case in South Africa, describes the parasite as follows:

"In contrasting the parasite with similar parasites in animals it approaches most nearly in its morphology *Tr. brucei*. It is the smallest of all described mammalian *Trypanosoma;* its average length is 22 microns including the flagellum; its breadth is greater in proportion to its length than in other parasites. The posterior part as measured from the micronucleus to the extreme tip is short and characteristic for this parasite.

"The micronucleus and its associated vacuoles are always large and well marked. The 'set' in fixed specimens differs from that of other species, as has already been pointed out.

"Doctor Laveran, who has very kindly examined some blood films taken from the patient, informs me that if the morphological characters are alone considered, he would regard my specimen as a new species; it differs from *Tr. brucei* in the length of the flagellum and in the small number of chromatin granules in the protoplasm.

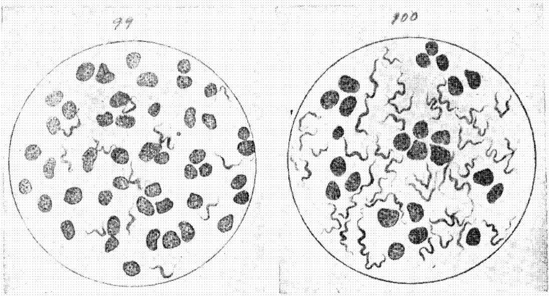
"Having as yet not had the opportunity of transferring the parasite in the blood from man to other animals, as has been so completely done in nagana by Bruce in Africa; Kanthack, Durham, and Blandford, and Plimmer and Bradford in England; Laveran and Mesnil in France; and to a less extent in surra by Evans, Steele, Lingard, Van Dyke Carter; and in dourine by Rouget, Nocard, and others, I am quite unable to contrast the pathogenicity and the morphological appearance of the human parasite in lower animals with the other species. It is to be remembered that no case has ever been recorded in man in the districts in which animal infection is so common, although man is exposed to the same risk of infection—for instance, the tsetse fly (*Glossina morsitans*, Westwood), which was proved by Bruce to carry the infection of nagana from animal to animal, bites travellers, natives and others, as well as animals.

"The consideration of these facts and the discovery of a parasite—evidently of the genus *Trypanosoma*—in the blood of a patient presenting symptoms markedly similar in very many points to those of the two or more diseases of lower animals which have been definitely proved to be caused by the presence of different species of the genus *Trypanosoma*, forces one to the conclusion that the parasite found in this patient is a new species, and is also the cause of the disease from which the patient is suffering. I would therefore suggest the name *Trypanosoma gambiense*."

Until more work has been done it is advisable to use caution in classifying this *Trypanosoma* as a separate species. It is done in this report tentatively, but the chances are that careful work will decide it to be identical with some of the others. There are several reasons for this assumption. The cases so far reported are from areas where the disease is prevalent in animals, and these cases are few in number and somewhat scattered. There are probably many cases which have not been detected, but we can not believe them sufficiently numerous to perpetuate the species without a host in some of the lower animals. It seems much more likely that there are changes in the patients which somehow interfere with their natural resistance for the well-known parasites.

Trypanosoma equinum Voges, 1901.
Trypanosoma elmassianii, 1902.

The length of this parasite, according to Voges, is two to three times and its width one-third to one-half the diameter of a red-blood cell. The anterior end is provided with a flagellum about as long as the body of the parasite, and extends backward about two-thirds the length of the body as a somewhat thickened margin of a distinct undulating membrane. The posterior end of the parasite is about one-third the length of the flagellum, and is contractile and somewhat beak-shaped. Its motion



FIGS. 99, 100.

Tr. equiperdum. 99, In the blood of a rat four days after inoculation; 100, same eight days after inoculation. (After Doflein, 1901, fig. 40.)

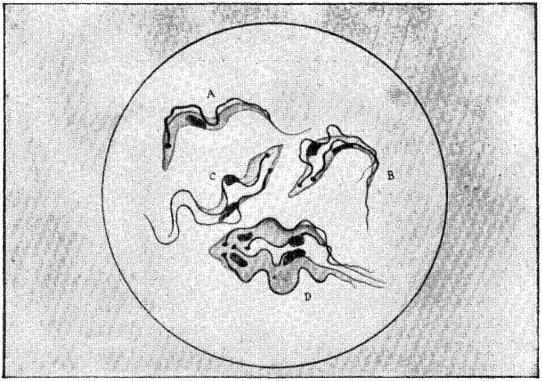


FIG. 101.

Trypanosoma of dourine in the process of evolution, clearly showing the centrosomes. Stained according to Laveran.

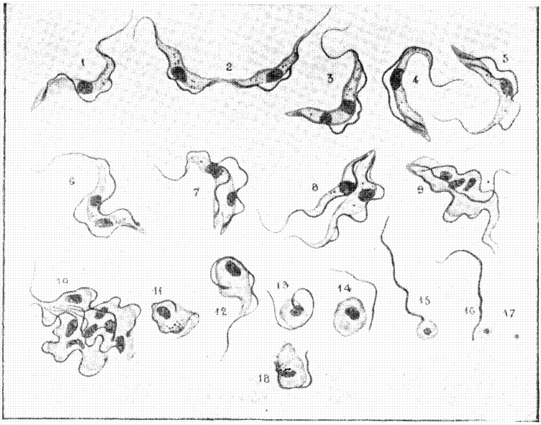


FIG. 102.

Trypanosoma of mal de cadéras without centrosomes distinguishable by staining according to Laveran or Romanowsky. (After Lignières, 1902.)

Explanation of fig. 102.

1, normal form; 2, two *Trypanosoma* united by their posterior extremities; 3, *Trypanosoma* showing the beginning of multiplication at the nucleus; 4, 5, *Trypanosoma* showing the beginning of multiplication at the flagellum; 6, *Trypanosoma* with two nuclei and two flagella; 7, division of the parasite commencing at the posterior part; 8, *Trypanosoma* commencing division at the front part; 9, *Trypanosoma* with three nuclei and three flagella; 10, large form of multiplication, very rare, with seven nuclei and seven flagella; 11, 12, 13, 14, 15, 16, 17, 18, abnormal forms of parasite.

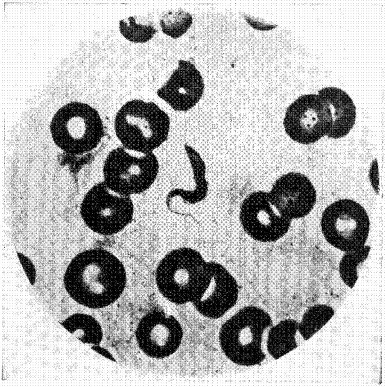


FIG. 103.

Showing *Trypanosoma* found by Dutton in the blood of a European. (After Forde, in Jour. Trop. Med., Sept. 1, 1902.)

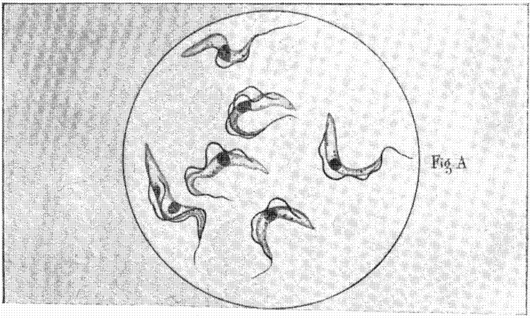


FIG. 105.—TRYPANOSOMA OF MAL DE CADERAS. STAINED ACCORDING TO LAVERAN. (AFTER LIGNIÈRES, RECUEIL DE MÉD. VÉT., 1902, PL. II.)

resembles that of an eel, but the actual motility is not great, the whole body taking part in an excessively active wriggling motion and the flagellum and beak ends moving in opposite directions. The motion is due to the undulations of the membrane, which run in both directions. The flagellum is the anterior extremity, but the parasite may move in the opposite direction. There is a nucleus toward the anterior and a centrosome near the posterior end, and the protoplasm is granular. In young parasites (rarely found) a larger speck (nucleus) is seen near the anterior and a smaller chromatin mass near the posterior end. The chromatin mass in stained specimens is sometimes surrounded by a bright area, which in turn is surrounded by a nonstaining border.

Habitat.—Similar to that of *Tr. brucei* and *Tr. evansii*, except for cattle, which are said to be immune.

Pathogenesis.—Pathogenic for domestic and certain wild animals. Voges considers the cattle of South America immune.

Trypanosoma theilerii Bruce, 1901.

Bruce has published a note regarding a new *Trypanosoma* discovered by Theiler in the cattle of South Africa. The new parasite is to be distinguished by its size, being almost twice as large as any of the others. It is pathogenic only for cattle.

Laveran and Mesnil have studied this *Trypanosoma* in specimens furnished by Theiler, and they agree that it is a new species. They give its length as 30 to 60 microns and its breadth as 2 to 4 microns. In its general structure and modes of division it does not differ materially from other *Trypanosoma.* They consider one of its diagnostic points the presence of blood cells with basophilic granules in the infected blood.

Habitat.—Blood of cattle.

Pathogenesis.—Horses, dogs, goats, sheep, deer, rabbits, guinea pigs, rats, and mice are said to be immune to this parasite, but Theiler was able to infect calves by inoculation.

Trypanosoma transvaaliense Laveran and Mesnil, 1902.

This *Trypanosoma* was discovered by Theiler in the cows of the Transvaal. Its dimensions are variable, the average being 30 microns in length by 4 to 5 microns in breadth. Its characteristic diagnosis is, according to Laveran and Mesnil, who have studied specimens submitted by Theiler, the presence of the centrosome near the center of the parasite and near and sometimes united to the nucleus. The altered corpuscle seen in blood infected with *Tr. theilerii* have not been seen with this parasite.

Habitat.—Blood of Transvaal cattle.

DIFFERENTIAL DIAGNOSIS OF TRYPANOSOMA OF MAMMALS.

Regarding the differential diagnosis of the *Trypanosoma,* which are of the greatest importance in the disease of domestic animals, there seems to be considerable difference of opinion, and the work will probably not be satisfactorily completed until all the supposed varieties are studied in one country in similar environments.

According to Laveran and Mesnil the distinction between *Tr. brucei* and *Tr. lewisii* is marked. *Tr. lewisii* is thinner and more tapering, and its undulating membrane is smaller and less folded. Its protoplasm colors less deeply. Its chromatin granules are not so large or numerous. Its posterior extremity is always thin and tapering and never has the appearance of a truncated cone. It lives longer on ice than does *Tr. brucei.* However, individuals showing no material differences are found in both varieties. In fresh blood without the presence of dividing forms they are differentiated with great difficulty. In *Tr. brucei* the centrosome always divides first, following which the flagellum, nucleus, and protoplasm separate in the order named. In *Tr. lewisii* division may begin in the nucleus, and before it takes place the parasite sometimes reaches 5 microns or more in breadth.

Tr. equiperdum, according to the same authors, closely resembles *Tr. brucei,* but the morphologic differences between the two are appreciable. *Tr. brucei* has much greater dimensions; its protoplasm colors more deeply and nearly always contains large chromatin granules, which are absent in *Tr. equiperdum,* which is never more than 20 microns in length. However, we have, in the blood of animals, seen *Tr. equiperdum,* which closely resembled *Tr. brucei,* that methods of differential diagnosis were unsatisfactory.

Tr. brucei and *Tr. equinum,* according to Laveran and Mesnil, have almost the same length and form. The protoplasm, the nucleus, the undulating membrane, and the flagellum have the greatest resemblance in the two *Trypanosoma,* but this is not true of the centrosomes. The centrosome of *Tr. brucei* colors easily and deeply and measures about 1½ microns in diameter; that of *Tr. equinum* does not measure more than one-third or one-fourth micron, and colors rose like the flagellum, and not violet like the centrosome of *Tr. brucei*. A number of chromatin granules difficult to examine are often found near it. Some observers have come to the conclusion that the centrosome is defective in *Tr. equinum*. Owing to the fact that the centrosomes differ in stained specimens of the blood of mice infected simultaneously with *Tr. brucei* and *Tr. equinum*, they have been able to distinguish the two species of *Trypanosoma*. The forms of multiplication are the same, double partition being the rule. Large divisions into three or four parts, which are somewhat more common in *Tr. equinum* than in *Tr. brucei*, are sometimes observed.

Martini considers the posterior end of *Tr. brucei* more blunt than that of *Tr. lewisii*, *Tr. equinum*, or *Tr. evansii*.

Buffard and Schneider and several others believe *Tr. rougetii* to be identical with the other *Trypanosoma* producing Trypanosomiasis in domestic animals.

Scheube, Bruce, Rost, Koch, and many others consider *Tr. evansii*, *Tr. brucei*, and some of the other parasites identical.

Lignières has recently written elaborately regarding the distinctions between the various *Trypanosoma* of mammals. In the main his results agree with those of Laveran and Mesnil already given, and his additional conclusions are, in some instances, based upon his misconception of the work of others.

A consideration of this subject resolves itself into two headings—first, a differentiation based upon microscopic observations of the parasites, and second, that based upon their pathogenic action. As might be expected, the more two parasites differ when compared by one of these methods the greater will be the difference between the two as determined by the other.

Tr. lewisii differs morphologically from the parasite of nagana, surra, etc., and these differences are confirmed by those in their pathogenic action. Concurrence of opinion on the individuality of *Tr. lewisii* as found in different countries is so universal that further attention need not be paid to it.

When we come to consider the identity or nonidentity of *Tr. evansii*, *Tr. brucei*, *Tr. rougetii* (*equiperdum*), and *Tr. elmassianii* (*equinum*), we are compelled to obtain our data for all of these parasites, except *Tr. evansii*, from the work of other authors.

Taking up first the study of morphologic differences, we fail to see any justification for the extremely careful and guarded conclusions of Laveran and Mesnil, or the very sweeping ones of several more recent authors. They have disregarded the fact of the variability of these organisms in the same species of animal in the same country, their greater variability in different species of animals in the same and in different countries, and other conditions requisite to identity of environment and to a conclusive comparative study. It must be remembered that we are dealing with organized animal life and that environment has an important influence on its physical condition.

The most important differences which conservative writers generally point out between these organisms are variations in the shape of the posterior extremity, the centrosome and the undulating membrane, and the granular condition of the parasite itself.

From careful observations we are confident that the posterior end of *Tr. evansii* is contractile, a condition which a few writers have noted in other parasites. This results in a variation of the shape of this extremity in *Tr. evansii*, and doubtlessly in other parasites, as great as that given for any two members of the group.

The same statement applies to some of the other supposed differences, such as variations in the undulating membrane and the general morphology of the parasite.

Another important factor which has not been given due consideration is the age of the parasite, as is also the condition, with reference to life, of the media from which the preparations are taken for study. In *Tr. evansii* and probably in some of the other parasites the number and size and to a certain extent the location of the granules depend upon the conditions mentioned. The difference in the staining of the centrosome in *Tr. brucei* and *Tr. elmassianii* (*equimma*), first emphasized by Laveran and Mesnil, we are not in a position to comment upon.

Laveran and Mesnil have written very carefully regarding the differentiation of these parasites, and are most conservative in considering differences in pathogenic action, regarding the latter as secondary in importance to the morphologic differences of the organisms. More effusive and less careful writers have drawn emphatic conclusions from pathogenic manifestations alone. There is undoubtedly a great similarity in the pathogenic action of the various *Trypanosoma*, in general the same animals being susceptible and showing similar symptoms and post-mortem lesions. The chief differences are those of degree, and they vary almost as much in different

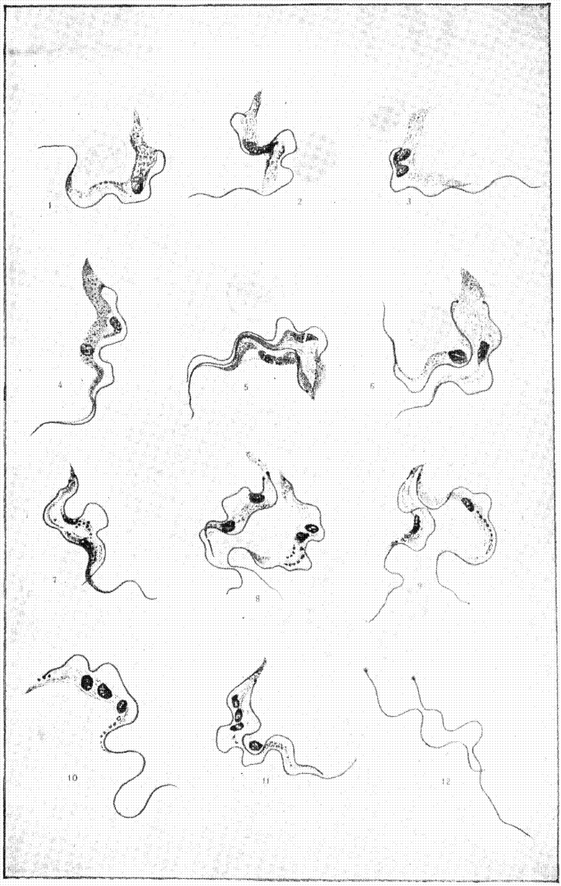


FIG. 104.

Tr. equinum. 1–6, Forms of multiplication in the blood of a horse; 7–9, same in the blood of a guinea pig; 10–11, polynuclear forms in the blood of a guinea pig in a state of gestation; 12, flagella and centrosomes free in a preparation made from the blood of a guinea pig in a state of gestation. (After Sivori and Lecler, 1902, Pl. IV.)

animals of the same species when inoculated with the same *Trypanosoma* as with different *Trypanosoma*. Cattle, for example, have been used to show differences in the parasites, when as a matter of fact in Manila these animals, when inoculated with *Tr. evansii*, show variations as great as those noted in literature for any two diseases.

After carefully reviewing literature and taking our own observations into account, we do not feel justified in forming a positive conclusion; but it seems to us that proof sufficient to establish the individuality of the *Trypanosoma* causing trypanosomiasis in domestic animals has not yet been advanced.

MODES OF TRANSMISSION AND INFECTION.

Believing as we do that the transmission of *Trypanosoma* by biting and stinging insects is the only method deserving consideration from a practical standpoint, we are in harmony with the best thought of modern literature on the subject. To demonstrate that this is the only practical method requires (1) evidence of a host constantly present in infected zones, (2) direct evidence of transmission from this host to the healthy animal, and (3) evidence that in the absence of either the host or the insects the disease is not communicated.

With reference to the presence of the host, we have ample evidence that it is constantly present in the different countries afflicted with *Trypanosoma*. It has been shown that in Africa elephants, camels, cattle, and other animals live for months and sometimes years with this disease, certainly long enough to carry the source of infection from one rainy season to another. Foá, Bruce, and others in this same country have shown conclusively that a certain percentage of the wild animals are infected and that they harbor the parasites with little or no inconvenience to themselves. They have further shown that when these animals are driven from a community, the biting flies to a large extent follow them, and in this manner the epidemic which may be raging at the time is almost completely suppressed. In India, camels, cattle, and other animals live long enough with this infection to carry the disease from one season to another; in fact the camel may live for more than three years. Rogers and others believe that in India the cattle, which live for months with *Trypanosoma* in the blood and often completely recover, principally act as the hosts. In South America wild animals and certain species of cattle when infected live for a considerable time and act as hosts in the propagation of the disease. Some of the recent writers in that country have concluded that horses are infected in sufficient numbers to act as hosts.

In the Philippine Islands with an epidemic of two years' duration it has been found unnecessary to go outside of the horse family to find a host constantly present. In Manila infected horses are found during the entire year, during the dry season, of course, in small numbers. The wild animals of this country have not been examined, and cattle, while susceptible to the infection, are rarely found to be naturally infected.

In literature there is an abundance of incontrovertible evidence to prove the disease to be transmitted from sick to healthy animals by biting insects, and this has been fully confirmed by our work, as will be seen below. There is also sufficient evidence to show that in the absence of either the host or the biting insects, the disease does not spread.

By contagion.—There is nothing in the nature of the disease or in the manner of its spread that in the slightest degree indicates transmission by contagion. The same may be said also of congenital transmission. Observers are unanimous in the opinion that the fetus in utero is not infected. We have performed a number of experiments in this line on dogs, monkeys, rabbits, guinea pigs, and rats. In one dog infected with *Trypanosoma* by inoculation about two weeks before delivery, miscarriage followed on the eighth day. In none of our other animals was gestation interfered with and the young were never found to be infected, though susceptible to infection. In one of our experiments two puppies were allowed to nurse from an infected mother in an insect-proof stable, and at the time of the death of their mother, eight days after their birth, they were free from infection.

By coition.—Almost all writers, referring to dourine, state that it is transmitted by coition, and a considerable number believe this to be the only method of transmission for this disease, while others believe it to be the exception even in this form of trypanosomiasis. This method of transmission has been given little consideration in relation to the other forms.

Recently some writers upon this subject have offered at least suggestive explanations. Schilling believes that transmission by coition occurs in those regions free from the usual infecting insects and from other conditions favorable to the propagation of the disease; and the geographic distribution of dourine would tend to support Schilling's conclusions. In infected countries, if the infection takes place by coition, it is lost sight of in the more frequent methods and could be determined only by careful experimentation.

We have performed a number of experiments looking to the elucidation of this point in the epidemic now raging in this country. Considerable difficulty has been experienced in obtaining direct evidence. Horses are not available for the work, and with the native ponies it has been almost impossible to find at the same time infected animals and those desiring intercourse. In several instances infected blood has been introduced into the vagina of female dogs by the use of a catheter. All these experiments except one have given negative results, and in the positive one infection is attributed to a lesion of the vagina. In those cases in which the mucous membrane of the vagina was injured purposely, infection following the introduction of virulent blood occurred in every case, with an incubation period equal to that following infection through the injured mucosa of the mouth.

We have not observed an absolutely conclusive result following coition. One male dog contracted the disease after intercourse with an infected female; but a small number of biting and stinging insects were present at the same time, so that it was probably transmitted by them. Upon another occasion an infected male goat was seen to copulate with a healthy female, but no infection followed. This was hardly the most desirable kind of an experiment, since the goat in question rarely showed parasites by microscopic examination, though his blood was infectious by animal experiment. Again, the manner in which goats effect copulation would be much less likely to result in infection than in the case of the horse, provided, as has been suggested, it depend upon traumatism. It seems more than probable, however, that in many animals, and especially in the case of the horse, infection might often follow sexual intercourse as the result of traumatic injury of the genitals. It is not uncommon to see a few drops of blood after sexual intercourse between these animals, and it would certainly require no stretch of the imagination to suggest the possible presence of small injuries in the mucosa of the genitals of both animals. It does not appear, however, that much importance should be given to this as a practical means of transmission of the disease. Any disease of horses transmitted only by coition could, of course, be eradicated with the greatest ease.

Rats as carriers of the infection.—In referring to the part played by rats we come to a much more important subject. To bring out its full significance necessitates a brief consideration of the natural infection of rats with *Tr. evansii*, a point which will be thoroughly discussed under "Trypanosomiasis of rats," and a consideration of the bearing such infection has upon the transmission of surra in animals of economic importance.

Rats, in an indefinite way, have been blamed for the transmission of the disease. Lingard has made elaborate experiments to show that grain soiled with the excrement of these little pests and eaten by horses plays an important part in the spread of the infection. He has demonstrated that rat surra is transferable to horses by inoculation; but, owing to his failure properly to protect his animals from insects, his work has received but little consideration. Musgrave and Williamson have shown conclusively that a certain percentage of rats in Manila harbor *Tr. evansii*.

In a preliminary report they say:

"A varying percentage of rats are known to harbor a *Trypanosoma* somewhat resembling the one found in the horse, and it has been conclusively shown that a certain number of rats in Manila harbor the same *Trypanosoma* which causes the disease in other animals. These parasites have been determined both morphologically and in their pathogenic action to be identical with the parasite causing trypanosomiasis in horses."

With this information we are prepared to consider the part they play in transmitting the disease to domestic animals and in perpetuating the epidemic. Rats frequently fight, and it has been shown that the infection passes from one to another in this way. In addition, the wounds so caused attract biting insects, particularly fleas, which are known to transmit *Trypanosoma* from rat to rat, and as will be seen later, from rats to other animals. In Manila the number of rats infected with *Tr. evansii* makes it necessary seriously to consider them in discussing means of controlling the disease in this city.

Infection of pastures, food, and water.—Infection through the sound mucosa and through the injured mucous membranes presupposes to a large extent as its source infected food and drink. Lingard, the great champion of this method of transmission, considers the ingestion of stagnant water and of grass from land subject to inundation a source of infection, the latter being a favorable breeding place for low forms of animal life and possibly of *Trypanosoma.*

Salmon and Stiles believe that there is nothing at present known in connection with the life history of any *Trypanosoma* to lead us to look seriously upon grass as a source of infection. We know that *Trypanosoma* die very rapidly under all usual conditions outside of the living body. If they are to be found in either food or drink, they must be in some phase of the life cycle with which we are unacquainted. If food and water should be infected, as Lingard maintains, they would still be harmless in the presence of the demonstrated fact that the disease is not transmittable through the sound mucosa of the alimentary canal.

In a preliminary report Musgrave and Williamson make the following statement regarding this subject:

"The existence of an extra-corporeal stage of *Trypanosoma*, living on grass and in water in marshy places, in this stage taken into the stomach of susceptible animals eating and drinking in these localities, and from this organ or other part of the animal economy passing into the blood in the forms we recognize, is without sufficient evidence to warrant consideration in this paper.

"Before leaving this subject, however, for a fuller discussion in a subsequent paper, it is proper to state that *Trypanosoma* quickly die under all tried environments outside of the body of some living creature, and no evidence of their existence in water, on grass, or other similar places can be advanced. Both water and grass have been inoculated with large numbers of *Trypanosoma* and have failed to convey the disease, after days, weeks, or months, when fed to susceptible animals, and also when injected under the skin.

"Malaria is similar to trypanosomiasis in that both are parasitic diseases and both are prevalent in low-lying, marshy lands and during wet weather. Malaria was for ages attributed to the air, the water, etc., of these marshes, and it took years to make the public understand that all these conditions are harmless in producing it, provided the patient is protected from the bite of mosquitos, so prevalent in these regions.

"Take the epidemic of trypanosomiasis in Manila. At the time of its outbreak and for some time afterwards, it was confined to the city. The grass and water given the horses were the same which had been fed for years, and no disease resulted.

"The disease started from a focus of inspection and spread directly with exposure to infected animals, and attacked alike animals fed exclusively on hay and oats and those fed on grass. The disease is prevalent in Manila at the present time and has been so continuously since its introduction. The majority of horses having the disease, under our observation for the past four months, had been fed previously entirely on hay and oats.

"In one large stable, with both American and native horses, four of the American horses and mules (fed entirely on dry feed) and two of the native ponies have died of the disease, and one of the two ponies was the only horse of this class in the stable which received dry feed only.

"The statement is made that certain districts in India are avoided by cavalry on the march because of the danger in these districts from food and drink through which animals may contract the disease. Similar conditions are found in South America, but in addition it has been shown that infected districts on this continent are just as dangerous to horses provided with dry food and pure water while passing through them as they are to animals eating forage grown on the spot.

"It has been shown by a number of observers that an infected animal taken to a new place becomes a focus for the spread of the disease, provided biting flies are present, no matter whether the territory is marshy or dry."

Since that time the work has been continued, but no evidence has been obtained to show that food, water, or pastures are ever factors in the spread of the disease.

Attempts artifically to infect water and grass have always failed. It is true that when these substances are used as culture media parasites may live for a short time under certain conditions, but multiplication to an appreciable extent does not occur. It is, of course, possible that infection may occasionally take place in localities where sick and healthy horses graze on the same ground or drink water from the same place, provided both classes of animals have lesions of the mucous membranes or cutaneous wounds on those parts of the legs which come in contact with the grass or the water. It is absolutely certain, however, that if food and water are ever infected to any degree it must be with some form of the parasite not yet known. Even if such places served as culture media for *Trypanosoma*, as we know them, they would still be comparatively harmless to those animals having sound mucous membranes and free from cutaneous wounds.

Infection through the sound mucosa.—There is some difference of opinion, especially among recent writers, in regard to infection by food and drink through the sound mucosa of the alimentary canal. Lingard affirms emphatically that the disease is so transmitted, but the great majority of recent investigators state with equal positiveness that the disease can not be so produced.

Kanthack, Durham, and Blandford attempted to transmit *Trypanosoma* by feeding, performing a number of experiments. At times they were successful, but in most cases they failed. They concluded that the possibility of infection depends upon accidental lesions of the mucous membranes of the upper portion of the alimentary canal. Continuing they say:

"Of a number of rats fed on the organs of nagana animals only a few acquired the disease, and these invariably showed superficial lesions of the snout and ears, due to lice. When fed upon infected material, they buried their snouts in it and scratched their ears with their blood-stained forepaws. Furthermore, in rats which acquired the disease through feeding, the cervical glands were always enlarged most, a fact which proves that hematozoal infection must have taken place in the head, for, as we shall show, the primary infection travels by the lymphatics.

"A cat fed repeatedly on the soft tissues of bodies of infected dogs and cats, and subsequently on the bodies of dead rats, died at a time corresponding by lethal period to an infection at the first meal on rats. We regard it as probable that some splinter of bone caused a superficial lesion, through which the hematozoa were enabled to enter.

"A rabbit fed carefully by means of a pipettee with large quantities of infected blood did not show the slightest sign of the disease. Rouget (1896) also failed to infect animals by the mouth."

Evans and Steel believe that surra can be transmitted either by ingestion or by inoculation in dogs, horses, and mules, provided that fresh infected blood is used. With blood kept twenty-four hours or more they did not succeed in conveying the disease.

Writing in 1899, Lingard considered that natural infection with surra might occur in one of four ways: (1) From eating grass and other vegetation grown upon land subject to inundation; (2) from drinking stagnant water during certain months of the year; (3) from the bite of certain species of flies, probably as carriers of the virus; and (4) from the ingestion of corn soiled with the excrement of rats and bandicoots.

Having determined that the *Trypanosoma* of rats in India was the cause of trypanosomiasis in a certain percentage of other animals, such as the horse, he experimented to prove whether this was of any practical importance in the spread of the disease. He mixed the excreta of rats with grain, which was fed to horses during the dry season in an area free from surra, with negative results. With similar experiments, however, under favorable conditions of moisture and heat he claims to have obtained positive ones. With regard to these, he writes as follows:

"At a later date, during the latter half of the hot season and the rains of 1893, further experiments with the same end in view were carried out in Bombay, where the climate is favorable from its humidity and the disease is enzootic. From these positive results were obtained, the incubation period occupying four months (about June to September), but the incubation period of the disease will probably be found to vary with the amount of moisture in the atmosphere and the amount of materies morbi ingested by the animal. This points to the probability that a number of surra cases in Bombay were contracted through the ingestion of rats or bandicoots' excreta mixed with the corn."

Salmon and Stiles doubt the accuracy of these results. They say that *Trypanosoma* have not been found in the excrement of either horses or rats; that it is not clear that Lingard used the necessary precautions to exclude fly bites and other factors in his experiments, and that if rats harbored *Tr. evansii*, transmission from them would have been as possible by rats' fleas as by their excrement. Voges fed animals with several liters of infected blood mixed into a paste without results. Laveran and Mesnil also failed to convey the disease through the sound mucosa. Rouget's feeding experiments were negative, but he obtained positive results by dropping infected blood into the conjunctiva. Rogers was unable to convey the disease through the sound mucosa, and says that in those cases in which infection occurred by feeding there were injuries of the mucous membranes. Rost writes that grass, grain infected by rat's excreta and flies must be considered in the etiology. Salmon and Stiles consider ingestion as a possible means of infection, but state that it can deserve no special consideration as a means of transferring the disease from horse to horse.

It appears to us that one of the strongest arguments against the transmission of the disease through food and drink is furnished by Lingard himself. He states that a street car company, which had lost hundreds of horses from surra, finally provided their animals with boiled drinking water only, and with grass brought from an elevation of 6,000 feet, prohibited the feeding of green vegetables, and also ordered the animals to be isolated, without success. It is to be noted that these stables were situated on a street along which infected horses were traveling, so that the isolation of the company's animals did not protect the healthy ones from flies. The manner of feeding did exclude infection by this means, and seems to us a strong point in determining that food and drink play absolutely no part in the transmission of the disease.

The numerous citations of instances in which dogs contracted trypanosomiasis by eating the carcasses of animals dead of the disease seem to us to be no argument in favor of its transmission through the sound mucosa. Such animals are always fighting, and the infection might readily take place through wounds, and in addition these animals are usually well provided with biting insects. Curry states that it is not known whether the disease in the Philippines can be transmitted by food and drink.

Our investigations have failed to produce the slightest evidence that infection by food, drink, or otherwise ever occurs through the sound mucosa. Musgrave and Williamson, discussing this mode of transmission, say:

"The great majority of writers agree that infection can not take place through the sound mucosa of the alimentary tract, and that the occasional infection following the administration by mouth of the virulent blood and organs of animals recently dead of the disease are probably due to the fact that these animals had damaged mucous membranes of the mouth or upper part of the alimentary canal, which would, of course, result in infection, just as would occur in any other part of the body by bringing an injured surface into contact with infectious material, or vice versa.

"In nearly all feeding experiments large doses of the infective agent have been given, and in this sense they have not approached natural infection, which, from the nature of things and whether administered through the mucous membrane or the skin, would be in small doses.

"Lingard attempted infection through the digestive canal by the administration of very small doses of infected blood, given frequently in large dilutions of water. One of his horses that had received such treatment, and in addition one dose of 13 c. c. of infected blood, developed the disease on the one hundred and thirtieth day after the beginning of the experiment. He fed a second horse 200 minims of fresh virulent blood at one dose, with an incubation period of seventy-five days. He does not state that these horses were protected from insects during the periods of the experiments, which were made in an infected country, and it is more than probable, considering the incubation periods of one hundred and thirty and seventy-five days, that his animals were infected in some other way.

"So far as we have been able to discover, there is not in literature any absolute proof of infection through the sound mucosa by feeding.

"In this preliminary report but one of our many feeding experiments will be given.

"Monkey No. 126—healthy adult male monkey—was isolated, temperature taken, and blood examined daily for a week. The temperature remained normal and the blood negative for *Trypanosoma*. After twelve hours' fasting, he was fed weekly for six weeks on cooked rice (the usual diet) soaked with fresh, warm, virulent blood, rich in *Trypanosoma*, from different animals at different feedings. On two occasions he was given to drink infected blood in weak potassium citrate solution, in which *Trypanosoma* live longer than in any other known solution outside of the body.

"At the end of six weeks the animal was apparently in good health, temperature had remained normal, and the blood free from parasites. In order absolutely to exclude the existence of infection, a drop of blood was injected subcutaneously into another monkey, which remained well and was afterwards proved susceptible. During the feeding the infected rice would often be stored in his chops and remain there for hours.

"After proving the animal not infected at the end of six weeks, a small scratch was made in the mucosa of the mouth and he was again fed as before. The disease developed on the fourth day, as was evidenced by rise in temperature and the presence of *Trypanosoma* in the blood. He ran the regular course of the disease, and died on the eighteenth day after infection."

This work has now been continued for more than a year, involving the use of hundreds of animals. We have experimented with horses, dogs, goats, rabbits, guinea pigs, monkeys, cats, and rats. We have fed them large and small doses of virulent blood and all kinds of preparations of both blood and infected organs. All experiments were performed under circumstances which made accidental infection impossible. Particular attention to this part of the subject was deemed necessary in order intelligently to recommend measures for the control of the epidemic. Our results have given absolutely convincing proof that infection does not occur through the sound mucous membranes by *Trypanosoma*, no matter in what form administered.

Infection through the injured mucous membranes.—As stated by Musgrave and Williamson in a preliminary report, surra is essentially a wound disease, and transmission through the injured mucous membranes results when infected material is brought in contact with it. When infection occurs through the alimentary tract it does so through a wounded mucous membrane. Monkey No. 126 was one of the many animals experimented upon to determine this point, as well as the possibility of transmission through the sound mucosa. Of course it was easy to prove that infection could occur through an injured mucous surface, but definitely to show of what importance this would be in the practical transmission of trypanosomiasis required more work.

It was necessary, first, to determine what percentage of a number of animals in the natural course of events have sufficient injuries to make possible an infection in a given period of time. Naturally this was found to vary greatly. In dogs and rats injuries are so frequent that in order to obtain animals without lesions to be used in determining the possibility of transmission through the sound mucosa we were compelled to confine each animal by itself for some time. In horses, cattle, and other animals of economic importance natural lesions of the mucous membranes are very rarely found. In horses used for carriage and draft purposes lesions in the corner of the mouth, caused by the bridle bit, are quite frequent. In the case of cattle and carabao lesions are seen in the nose around the ring which is placed through the septum and which usually has a rope fastened to it. Small wounds might occasionally be produced in the mouth by eating rough, dry food.

With injuries present in the mucous membranes, the next question to consider was the manner in which infectious material may be brought in contact with these wounds; and from a practical standpoint (excluding flies) there are not many possibilities. All such means are of course mechanical, and readily suggest themselves. They are: Changing bridle bits from sick animals to healthy ones, allowing healthy animals to lick sores on sick ones, placing animals to graze upon the same ground or allowing them to drink the same water, etc.

Here may be introduced a strong argument against the theory that food and water play a serious part in the transmission of the disease. If such were the case, animals with wounds would contract the disease from eating and drinking food and water which had been allowed to stand just as readily as they do when freshly infected material is fed to them, but this is not the case. We have experimented on animals with fresh wounds, feeding them water and grass infected from forty-eight hours to three months previously, and kept under all kinds of conditions, but have failed to convey the disease in this manner.

Flies.—Of the biting insects that play a part in the transmission of the disease, certain varieties of flies are of the greatest significance.

Of flies credited with playing an etiologic rôle in this disease, the tsetse fly (*Glossina morsitans*) is among the most important.[a]

Schilling states that *Glossina logipalpis* is very prevalent in Togo, as well as *Stomoxys calcitrans* and three species of *Tabani*. He regards all these varieties as able to transmit the infection. He proved conclusively that at least two species of these flies can transfer the infection in dogs.

Martini found normal *Trypanosoma* twenty-three hours after feeding the *Stomoxys calcitrans* on infected blood, the insect itself being kept in a room at a temperature of 23° C.; but he did not see dividing forms. On the following day the blood was digested and the parasites could not be observed. On dogs, biting experiments with these flies failed. Healthy horses and asses standing next to sick horses, all covered with *Stomoxys calcitrans*, did not contract the disease. Martini's work was performed in Berlin.

Working in Manila, Curry considered the *Stomoxys calcitrans* as the principal agent of transmission and found enormous numbers of them feeding on sick animals. He observed active *Trypanosoma* in the proboscides and stomachs of these flies twenty-four hours after their feeding upon infected blood. He was unable to find *Trypanosoma* in any other species of flies. Rost found *Trypanosoma* in juices squeezed from the horsefly some hours after feeding on a surra animal, and he was convinced that these transmit the disease.

Lingard describes an epidemic in India in which flies were very numerous and no precautions to isolate or destroy infected ponies were taken. Sixty-five animals died in the region in question. During the next season, however, in the same locality and among the same class of horses, the infected animals were isolated and only two deaths occurred. He demonstrated that the body fluids of certain flies contain

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[a] We had hoped to introduce here a short illustrated description of each species of flies, which have been credited with playing a rôle in the transmission of *Trypanosoma*, but the pressure of other work has prevented the entomologist, to whom the duty was assigned, from completing the undertaking. At some future time we hope to be able to do this, when we shall also finish the discussion of some of the points left open in this paper.

Trypanosoma after feeding on infected animals and that the inoculation of such fluids in susceptible animals causes the disease. He and his assistants examined large numbers of *Diptera* of some ten varieties, during both the dry and the wet season, but *Trypanosoma* were not found in any case, except in adult flies which had fed on infected animals.

Sivori and Lecler in South America proved that the *Musca brava*, the *Stomoxys calcitrans*, and the *Taon* can transmit the disease from horse to horse. The relative of these flies, *Ochleretatus obifasciatus*, also showed *Trypanosoma* after feeding on a sick horse, but did not prove capable of transmitting the infection.

Voges states that the disease is transmitted only through wounds, injections, etc. Several varieties of *Tabani* are found in South America, and the *Musca brava* is also prevalent, as well as various kinds of mosquitoes.

Wasielewski and Senn consider *Tabani* as active factors in the transmission of the disease.

Rogers proved conclusively that surra is transmitted by flies which have recently bitten infected animals. Infected flies kept from one to four days did not transmit the disease by biting, and were harmless when fed to rats.

Bruce considers the tsetse fly able to convey the disease for forty-eight hours after feeding on infected blood. He placed five muzzled horses in areas containing flies, and notwithstanding the fact that they were all prevented from using the food and water found there they contracted the disease. Suspected flies transferred to a district free from nagana conveyed trypanosomiasis by biting two dogs after four to seven hours. He found living *Trypanosoma* in the proboscides of these insects forty-six hours after they had fed on infected blood, and in their stomachs one hundred and eighteen hours after feeding; but at the end of one hundred and forty hours no parasites were present.

Schilling noticed that at a certain place in Africa on one side of a lagoon 3 kilometers in width surra and tsetse flies were prevalent, while on the other side neither could be found.

Without going into further detail there is abundance of incontrovertible evidence that the disease is transmitted by a number of species of biting flies, as was the opinion of the natives of India and Africa long before science demonstrated the fact. It has thus far been conclusively shown that the tsetse fly (*Glossina morsitans*), at least one other variety of *Glossina*, *Stomoxys calcitrans*, *Musca brava*, *Taon*, and at least one variety of *Tabani* transmit the disease. All other biting insects have been looked upon with suspicion, but absolute proof of transmission by them has not been furnished.

Is it a mechanical action or is it one phase of the life cycle of the parasite which takes place in these insects? The time limit of infectfon in all conclusive experiments has been too small to admit of any other construction than that the action is mechanical. This is the conclusion of nearly all modern writers. Schat, whose work has been mentioned above, is the only exception, but his experiments do not confirm his theory that a phase of the life cycle of the parasite takes place in the fly. The time limit of infection for these insects is given by most authors at twenty-four hours, and a few place it as high as forty-eight. Agreeing with Salmon and Stiles, we must say that a phase of the life cycle in insects is certainly not necessary to a definite continuation of the infection, and it is extremely doubtful that it exists.

We have transferred the infection to monkeys by biting flies in experiments so guarded as to make the results absolutely conclusive. We have also transmitted it by means of the common house fly from an infected dog having a wound to a healthy one in a similar condition. Monkeys are difficult to experiment with, for the reason that they take pleasure in destroying all flies coming near them, but we succeeded in performing our experiments by placing one of the animal's legs in a test tube containing flies which had recently been fed on infected blood. These experiments have been repeated, and the transmission of the disease to the horse, dog, monkey, rat, and guinea pig by biting flies has been confirmed. Our work has been conducted with the greatest care and in all cases controlled by animal experiment. In short, the transmission of the infection in this way has been so frequently shown that further demonstration hardly appears necessary.

With these facts before us, however, we have yet to discuss the very important part of the subject which refers to the rôle which these insects play in the practical dissemination of the disease. This, of course, is difficult to prove by direct experiment without great expense and trouble, but the evidence showing this to be the usual method of transmission is so conclusive as to render such experiments unnecessary.

Summarized, this evidence is as follows: It has been repeatedly shown that biting flies can transmit the infection. It has been proved that animals protected from insects do not contract the disease, but that when protected from every other source of infection but this one trypanosomiasis occurs with the usual regularity. Finally, no other suspected method of transmission explains why they are found in zones where the disease is epidemic.

Fleas.—Plimmer and Bradford and Rabinowitch and Kempner have shown conclusively that fleas may transmit *Tr. lewisii* from rat to rat; and it has been suspected that they may play a similar rôle in the more important animals, although this suspicion had not, at the time this work was taken up, been demonstrated.

With reference to the transmission of the disease by fleas, our own work has been absolutely convincing. Surra has been transferred by these insects from dog to dog, from rat to rat, and from rat to dog. Horses have not been used for this work because of their cost and the apparent uselessness of wasting expensive animals without material gain in information.

Sources of error in this work were eliminated in the following manner: The dogs were placed in an area covered with sand and protected from insects by screens. All but one of the dogs were then taken from the stable, and this one we proved to be free from *Trypanosoma* by animal experiment. A surra-infected dog was then placed near by but separated from the other one by a screen to prevent them from touching each other, but at the same time allowing free passage to the fleas. The healthy dog developed the disease on the sixth day, as evidenced by a rise of temperature and the presence of parasites in the blood. This experiment was repeated a number of times with positive results. The time intervening between the admission of a dog and the first positive evidence of disease (as nearly as the incubation period could be estimated) varied from five and one-half to twelve days.

All animals were then removed from the flea-infected area and only healthy ones introduced after periods of time varying from twenty-four hours to four weeks. Although the fleas in the sand remained quite plentiful no infection occurred.

Rats in screened cages placed in this flea-infected area in close proximity to an infected dog contracted the disease. The dog was then removed and a cage of healthy rats substituted, some of which contracted the disease.

These observations have removed fleas from the doubtful means of transmission and proved them to be a factor to be carefully considered in our efforts at prevention. Fleas are very numerous in Manila, especially so during the wet season, when trypanosomiasis is most prevalent.

Mosquitoes.—Beyond the bare mention of the possibility that these insects may transmit *Trypanosoma*, we have been unable to find any records in literature, and because of the lack of time our experiments in this direction have not been as thorough as we desired.

A number of experiments have been performed, all of which have been negative, and were carried out with young monkeys and guinea pigs in the following manner: A young guinea pig with parasites in its blood and a healthy one were placed in a large mosquito-proof cage and separated from each other by a coarse wire screen. Mosquitoes were then placed in the cage in large numbers, and more were added when necessary. The experiment was continued for a month without results.

Misquitoes were allowed to feed upon infected blood and then placed in a large test tube, into which a monkey's arm was introduced and allowed to remain for three hours at a time. The experiment was repeated daily for a week, but no infection occurred.

The mosquitoes used in these experiments were *Anaphales*, *Stigomyia*, and *Culex*. These varieties are all very prevalent in Manila, but do not appear to disturb domestic animals greatly; and for that reason, even if they sometimes carry the infection, as is likely, they deserve only secondary consideration in discussing the spread of surra in horses. It is more than likely that the large gnats found in swampy places and which attack large animals are important factors in the transmission of trypanosomiasis.

Lice.—These little pests are repeatedly mentioned in literature as possible agents in the transmission of the different forms of trypanosomiasis, but, so far as we have been able to determine, there is no direct evidence furnished that such is the case. It certainly appears possible that the disease may be transmitted by lice, especially in the case of animals, such as rats and other small animals, suffering from wounds; but, as far as the larger ones are concerned, we can hardly consider these insects as a practical means of dissemination for the disease. We have repeatedly performed experiments on monkeys, dogs, and guinea pigs in order to determine this point, but so far they have failed to give positive results; nor have we been able to find *Trypanosoma* in lice caught on the bodies of infected animals.

It has already been pointed out that lice are very numerous on rats and help to cause small wounds on these animals, especially around the ears. They are also exceedingly numerous on carabaos, but do not appear to produce any injury to these thick-skinned animals.

Ticks.—As in the case of lice, ticks have been blamed by a number of writers as agents in the transmission of the disease. Voges does not believe they play an important rôle, for the reason that a tick no sooner injures the skin than it absorbs the blood of the surrounding tissue by suction, and as soon as this is accomplished falls to the ground. The feedings of the tick are so far apart that *Trypanosoma* would not likely be carried by them from one animal to another. This logic seems to us to be very satisfactory and has been accepted without experiment.

Enormous numbers of ticks are present in certain sections of the Philippines, and if they were agents in the spread of the disease they would merit very careful consideration.

Infection through open skin wounds.—From what has already been said in discussing infection through the injured mucosa, it will readily be seen that skin wounds are a constant source of danger during the prevalence of the disease. Such places entice flies, which can undoubtedly infect wounds with greater ease and certainty than they can uninjured skin surfaces. With the presence of skin lesions there are many additional possibilities to be considered, which may be disregarded in dealing with sound animals. These may vary somewhat with environment, but in no case are they of frequent occurrence. Musgrave and Williamson mention among these agencies the passing of currycombs, brushes, etc., over wounds on sick animals and then over similar places on healthy ones.

With a fuller understanding of rat infection a more important point may be raised here. This has not been actually demonstrated, but with the knowledge already possessed of the transmission of the disease by fleas, open sores on the lower extremities would be subject to infection by these insects, and in this way it would not be surprising to find them playing an important part in transmission, especially in a country like this, where minor injuries to horses' legs are so common and fleas so numerous.

Miscellaneous.—Lingard has brought out the point that the disease may accidently be transferred by birds picking sores on infected animals and following this on noninfected ones.

Railways have been mentioned as factors in the transmission of trypanosomiasis, and when they become more numerous in some of the infected zones they will no doubt play an important part in the spread of the infection, since they make possible a more rapid distribution of animals and also a greater dissemination of flies. However, as a means of transmission deserving consideration from a practical point of view in the Philippines, the possibility is very remote.

Theiler believes that in South Africa the propagation of the disease to a limited extent is influenced by the immunization of cattle against rinderpest with defibrinated blood. In Manila we have had a striking example of this possibility. Doctor Jobling, director of the serum laboratory, received from Java a number of cattle for serum work. One of these developed rinderpest and was bled to death, the blood obtained being used on four serum animals, three of which promptly developed surra and, of course, became useless for serum purposes. The infection in these cases undoubtedly came from the Java cow and illustrates too well what, as suggested by Theiler, no doubt frequently happens.

In following the discussion of the modes of transmission and infection it is seen that but few of the headings which have been chosen really have any practical significance; and we may well close this part of the subject with the statement, already emphasized, that trypanosomiasis is essentially a wound disease and that infection takes place when materies morbi are brought in contact with an injured surface and in no other way. The most common agents in bringing this condition about are biting and stinging insects, and of these certain flies and to a less extent fleas are the most important.

The manner of perpetuation.—The manner of perpetuation of a disease of this kind is interesting, since it has a practical bearing upon methods for its control. The eradication of the disease may with propriety be discussed at this point.

Musgrave and Williamson in a preliminary report, referring to this question, say:

"The manner of perpetuation of an epidemic of trypanosomiasis in any country is a very important point in considering the prevention and eradication of the disease.

"By the very nature of parasites and of parasitic diseases in general, we know that unless the disease is continuous the parasite must have a natural host, or there must be a stage in its life cycle in which it can exist for an indefinite period outside the living body; otherwise the infection will disappear.

"Many of the large tsetse fly areas are absolutely destitute of domestic animals and probably some of them have never had one within their borders, and yet the flies in these districts are capable of infecting domestic animals. As it has been quite conclusively shown that the fly is not capable of carrying the infection at most but a short time it necessarily means that there is a source of infection from which the flies are supplied, and the natural inference would be that the native source of infection is the wild animals in which the country abounds. It has already been shown that some of these animals are susceptible to the disease and that others harbor the parasites with little or no inconvenience. It is very probable that, were inoculation methods instead of microscopic blood examinations used for diagnostic purposes, a much larger percentage of these wild animals would be found infected than has generally been supposed.

"Conditions in certain sections of South America are very much like those in Africa, and the indications are that the epidemic is perpetuated there in the same manner.

"In India some observers claim that the cow acts as a host for the parasites over the long dry period in which there are not enough cases in horses to continue the infection. The probabilities are that a number of wild animals which exist in at least certain districts of India aid in this continuation. It is claimed that in certain sections of the country there are two varieties of animals which live in the bush, are susceptible to rinderpest and foot and mouth disease, but are not known to have 'surra,' though they are in infected areas. At certain seasons the flies are so numerous that these animals seek the open for protection from them. It would be interesting to test the blood of these animals by inoculation to see whether or not they are free from trypanosomiasis. In India camels also may play an important part in carrying the infection from one fly season to the next, as it is stated that these animals may live as long as three years after infection.

"From the foregoing, and if the disease continues to spread, it is evident that the wild animals of this country must be considered in dealing with the epidemic. If a certain portion of them are not already infected, it is only a question of time until they will be, and another difficult point in the solution of the problem will thus be produced.

"The part that rats play in perpetuating an epidemic has not yet been fully determined, but the fact that at this time, in the middle of the dry season, a considerable number of these animals are found to be infected, and with the knowledge before us that the infection may be transmitted from one rat to another by fleas, which are numerous on rats at all seasons of the year, makes it probable that these animals play a very important part in perpetuating the infection in the Philippine Islands and in other countries.

"However, so far as the city of Manila is concerned, it does not appear necessary to leave the horse family to discover how the infection is perpetuated. Now, even during the dry season, one can, almost daily, see a horse, sick with surra, driven along the streets; and biting flies, although not by any means as numerous as during the wet season, are still plentiful enough to continue the infection.

"The existence of an extra-corporeal stage of the *Trypanosoma*, living on grass and in water in marshy places, in this stage taken into the stomach of susceptible animals eating and drinking in these localities, and from this organ or other part of the animal economy passing into the blood in the forms we recognize, is without sufficient evidence to warrant consideration in this paper.

"Before leaving this subject, however, for a fuller discussion in a subsequent paper, it is proper to state that the *Trypanosoma* quickly die under all tried environments outside the body of some living creature, and no evidence of their existence in water, on grass, or other similar places can be advanced. Both water and grass have been inoculated with large numbers of *Trypanosoma* and have failed to convey the disease, after days, weeks, or months, when fed to susceptible animals, and also when injected under the skin."

Since writing the above, much information has been obtained with regard to the part rats play in the spread of the disease, and the evidence makes it important that these pests be taken into account in discussing the perpetuation of trypanosomiasis.

It is not believed that the rats of Manila were infected previously to the advent of surra, and this is supported by the evidence obtained by an examination of rats taken from zones free from the disease.

Surra beyond question is transferred from rat to rat, so that these animals soon become important factors in its perpetuation in certain zones. In Manila the annual destruction of thousands of rats with the purpose of preventing the spread of plague will also have a beneficial effect in limiting one agent in the transmission and perpetuation of surra.

GENERAL PATHOLOGIC ANATOMY.

Generally speaking, writers have been very brief in their description of the anatomical lesions of the different forms of trypanosomiasis, the majority agreeing that they are not constant or pathognomonic. Some, however, have held different views, and have given excellent descriptions of their post-mortem findings, particularly Voges, and Sivori, and Lecler.

Laveran and Mesnil say that "nagana is certainly one of the diseases in which, at the autopsies of animals dead from the disease, there are slight lesions. Nearly all authors agree in giving as a constant lesion hypertrophy of the spleen. At the autopsy of one horse lesions of the internal organs were insignificant."

Voges states that in mal de caderas post-mortem examinations show œdema and roughened hair, just as they are present during life. The skin is removed with difficulty, and when taken off a very dry flesh similar to that seen in cholera is observed. Cloudy serous fluids are usually found in the serous cavities, especially of the chest, which may contain several liters. There are fibrous layers on the pleura and other serous surfaces, especially marked on the abdominal organs. The subpleural lymphatic glands are often enlarged. The spleen is enormously enlarged, sometimes hard and firm, and in other cases soft and friable. The follicules are often increased in size until they resemble grains of sago. The liver is enlarged. The kidneys are pale, and sometimes enlarged; the lymphatics are slightly so. Fluids are often found in the larger socket joints.

Schilling, writing of surra in Africa, says that post-mortem examinations show marked anæmia, especially of the lungs, and numerous, discrete, dark-red, subpleural spots; enlarged, soft spleen; enlarged follicles, and slight swelling and softness of the lymphatics of the neck, which contains a small amount of yellowish, opaque fluid. No special changes are observed in the liver and kidneys.

Sivori and Lecler, writing of "surra americain," state that the adipose tissue is replaced by a gelatinous mass. The muscles have a rose tinge, but are pale and in paretic cases may atrophy. Citrin-colored fluid is present in the peritoneal cavity. The liver shows some increase in consistency and is darker in color. The spleen is enlarged and the glomerules are prominent and red; in the paraplegic form it is greatly increased in size and the lesions intensified, sometimes producing acute splenic tumor. There is enlargement of the Malpighian corpuscles, which are often so increased in volume as to stand out in relief on the surface. The bladder contains pale urine, which may show traces of albumen with or without blood or biliary pigments. The pleural cavity sometimes shows a small amount of exudate. The lungs may be normal or œdematous and in places congested. The pericardial cavity contains a yellowish serous fluid. The myocardium is pale and friable. The cardiac fat shows the same gelatinous changes as those of the subcutaneous tissues, and may show ecchymoses. The endocardium, particularily the left, has subserous punctate hemorrhages. The brain shows only an increased amount of subarachnoid fluid. Sections of the spinal cord usually show no lesions, but there may be small hemorrhages in the gray matter. These authors do not consider all the lesions attributable to *Trypanosoma*, some of them being due to secondary infection. They do not believe *Trypanosoma* destroy the red blood cells mechanically, but think they are destroyed by mononuclear macrophages. The mode of production of œdema, they say, is unknown.

Bruce mentions as the anatomic lesions in nagana a gelatinous atrophy of the subcutaneous tissues, subserous and subcutaneous ecchymoses, and enlargement of the spleen.

Weber and Nocard, writing of dourine, say that the section shows cachexia and hemorrhagic softening of the spinal marrow. The parasites found in these areas and in the serous effusions resemble those of surra, nagana, etc.

Kanthuck, Durham, and Blandford give as marked lesions enlarged lymph glands, especially around the inoculated wound, hypertrophy of the spleen and liver, and often fatty degeneration of the latter. Iron reaction is obtained with the liver, the spleen, and the kidneys.

Curry gives as the principal anatomic lesions marked pernicious and progressive anæmia, general subserous œdema, especially of the belly, sheath, and legs, moderate glandular enlargement, frequently broncho-pneumonia and bronchitis; and often profuse muco-purulent nasal discharges, with marked glandular enlargement, particularly of the submaxillary glands.

In our experience necropsies have revealed anatomic pictures rarely as characteristic in the chronic diseases peculiar to man. The antemortem lesions, provided the necropsy is made shortly after death, are still present. The body is emaciated, and the bands of œdema, so prominent during life, may still be seen. A small amount of yellowish-tinged, gelatinous mucoid substance is found in the inner canthi of the eyes and even in the nostrils. The hair is roughened and often scant, leaving a scrawny, roughened epidermis. The mucous membranes are pale and dry looking and often show a yellowish tinge. The hide, as pointed out by Voges, is removed only with great difficulty, except in areas of subcutaneous infiltration, and when removed exposes the dry, hard, pale subcutaneous tissues. In the regions corresponding to the œdema during life are found yellowish-tinged, gelatinous infiltrations, which are of a similar consistency. A like condition is found throughout the body in the regions where adipose or areolar tissues are located, and especially is this true of the fat around the heart and the subperitoneal tissues. The muscles are pale, wasted, coarse, and granular looking. The serous surfaces, particularly the peritoneum and the pleura, often show flakes of plastic fibrous material. These are particularly numerous over the surface of the liver and sometimes in the spleen. All the tissues and organs have a peculiar dry, pale appearance, which has been so aptly compared by Voges to their condition in cholera. There are numerous subserous hemorrhages, particularly on the right side of the heart and over the lower portions of the lungs. The lymphatics are in general somewhat enlarged, and often markedly so; and in a certain percentage of cases areas of broncho-pneumonia are present. The heart muscle shows parenchymatous changes, depending somewhat on the duration of the disease. Its chambers usually contain chicken-fat clots, which often extend for a foot or more into the aorta. The appearance of the spleen varies somewhat, but in the majority of cases it is considerably enlarged, friable, and somewhat soft. The surface is uneven, due to the enormously swollen corpuscles, which stand out prominently on the surface. On section a typical sago spleen is often seen, while in other cases a typical acute splenic tumor, such as is present in infectious diseases of man. In a few cases the spleen is but slightly swollen, but the dotted appearance, due to the swelling of the corpuscles, is a constant lesion and gives to this organ, regardless of its size, a most characteristic picture.

The liver is usually somewhat enlarged, pale, and cloudy. The intestine shows lesions due to anæmia, with now and then small ulcerations in the upper portion and sometimes in the cæcum. The aqueous humor is often cloudy and contains *Trypanosoma*. The urticarial eruption observed during life is no longer evident. In some of the lower animals the scrotum, and even the testicle in the male and the vulva in the female, is greatly enlarged, and in the male rabbit the tension may be so great as to rupture the scrotum. Small prepucial or labial ulcers are not uncommon.

GENERAL REMARKS ON SYMPTOMATOLOGY.

Before proceeding to the study of trypanosomiasis in the various animals, it might be well to make a few remarks on the symptomatology of the disease.

There is considerable variation in the clinical picture of surra in the same class of animals, even when the infecting parasites are known to be the same, and it is therefore not surprising that variations should exist in different species. In reviewing the literature relating to dourine, nagana, surra, and mal de caderas, one is struck with the great similarity in the descriptions of the so-called different diseases. A comparison of the descriptions of any one of them, as given by different writers, shows as great a divergence as may be found with those of the diseases acknowledged to be different. In all of them, however, there are a number of practically constant characteristic symptoms in the well-established infection such as to make, when taken together, a clinical picture easy to determine accurately, even without the aid of the microscope.

After an incubation period, which varies in the same class of animals and in those of different species as well as with the conditions of infection, and during which the animal remains perfectly well, the first symptom to be noticed is a rise of temperature, and for some days a remittent or intermittent fever may be the only evidence of illness. Later on the animal becomes somewhat stupid; watery, catarrhal discharges from the nose and eyes appear; the hair becomes somewhat roughened and falls out in places. Finally the catarrhal discharges become more profuse and the secretion more tenacious and even purulent; marked emaciation develops; œdema of the genitals and dependent parts appears; a staggering gait, particularly of the hind parts, comes on and is followed by death.

Voges divides the symptoms of mal de caderas into two stages, as follows: On the fourth or fifth day after inoculation the temperature rises rapidly, sometimes to 40° or 41° C., and then suddenly falls to normal or nearly so, usually on the second day. Within five days there is another rapid rise, reaching 40° C., followed by another sudden fall. These reactions may be repeated from 2 to 8 times during the course of the disease. This is called by Voges the first stage. During this period the appetite is good and there is no emaciation. The thirst is increased. The feces are normal, but in rare instances may show a little clotted blood. Transient hemoglobinuria. The reflexes are normal. The coat is smooth, and the hearing and sight normal. Toward the end of this stage weakness becomes noticeable.

In the second stage the fever becomes less intermittent and exacerbations to 40° C. or over are exceptional. The remissions are also less marked. The animal becomes inactive and sluggish and allows the head to drop carelessly. Progressive emacia-

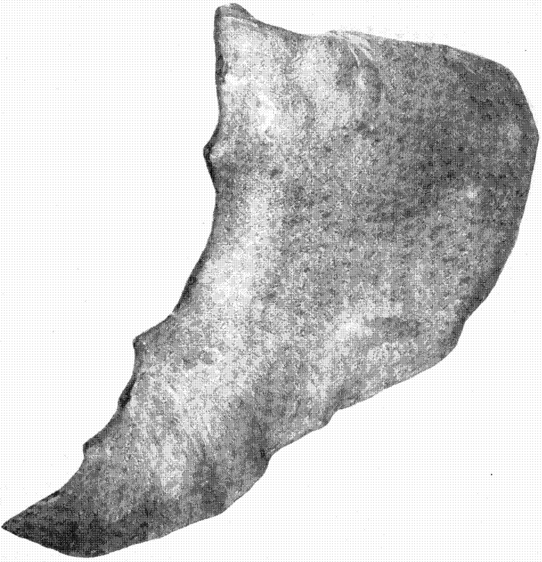


FIG. 106.—SPLEEN OF A HORSE DEAD OF SURRA, SHOWING ENLARGED FOLLICLES AND HEMORRHAGES.

tion takes place. Great thirst. Progressive weakening. Œdema, particularly of the hind legs, belly, and scrotum. The hair loses its gloss. Decreased sensibilities. Digestion and respiration remain good. The gait becomes staggering and finally causes the animal to fall over. Some animals die suddenly during the later stages of the disease. Just before death the temperature variations usually become greater, vacillating between 34° and 39° C.; and death generally occurs when the temperature is low.

The fever is not continuous or characteristic in any of these diseases. It may be intermittent, remittent, or, according to some writers, relapsing in character, varying from 39° to 41.5° C. It is nearly always higher in the afternoons.

In describing the epidemic of surra, which visited Java in 1900, Schat gives among the symptoms of the disease some which are remarkable in that they differ radically in many respects from those described by other observers. In reading his work one is struck by the fact that they form a very clear description of rinderpest in carabao. He found *Trypanosoma*, however, and it would appear to us that he was working with a combination of the two diseases.

A great deal of work has been done by various writers to demonstrate the relation of the temperature to the number of parasites in the circulating blood, some maintaining that these are numerous in proportion to the temperature and others showing that no relation whatever can be determined. Kanthuck, Durham, and Blandford say that the parasites appear in the blood early in the disease and continue to increase until death. The counts vary and may reach 2,000,000 to 3,000,000 per cubic millimeter. The parasites appear to multiply first in the lymphatic glands around the point of inoculation and then to enter the blood, a fact which they believe explains the short latent period during which, after inoculation, they can not be found in the blood. Multiplication occurs also in the infected area.

During the incubation period parasites are not found in the blood by misroscopic examination. This has been explained in various ways. Voges considers this to be because of their rarity, while others maintain that a stage of multiplication goes on in the lymphatics. A few conclusive experiments by animal inoculation, however, have shown that the circulating blood is infectious for one, two, or even several days before parasites are found by microscopic examination to be present, which would seem to indicate, as has been suggested, that they exist in the blood in small numbers during at least a portion of the time.

The periodical disappearance of the parasites from the circulating blood for varying lengths of time during the course of the disease has not been satisfactorily explained. All kinds of conjectures have been offered, with but little evidence to support them. Voges's idea regarding this seems to us to be the most plausible. He states that the parasites are numerous during the first few days after the rise in temperature, following which they mysteriously disappear; and this appearance and disappearance may take place a number of times during the course of the disease. He considers it due to a certain amount of immunity which is acquired by all animals in the early stages, and which may be repeated a number of times before the animal becomes too weakened. This view is advanced in preference to the opinion that the temperature plays any part in this phenomenon. In the later stages of the disease parasites may be found in the blood in larger numbers and with a higher temperature than at any time previously.

Another symptom in this disease, difficult of explanation, is the anæmia, which is progressive from the first. It has been explained that the parasites mechanically destroy the red blood cells and interfere with their manufacture in the bone marrow, and finally, that on account of certain changes produced in the blood by the parasites, the red blood cells are taken up by the large mononuclear macrophages. A number of less important explanations have been given. According to Voges, anæmia is a constant, prominent symptom; and 10,000,000, the normal number of red blood cells in the horse, may be reduced to 4,000,000, 3,000,000, and even 800,000 in some cases before death. The sedimentation ring of leucocytes is increased and may be larger than that of the red blood cells. The hemoglobin is decreased in proportion to the diminution in the number of red blood cells; from the normal of 13.1 per cent it may fall to 3 or 4 per cent.

Several observers have spoken of the mechanical destruction of red blood cells by the parasites. Voges saw *Trypanosoma* hold erythrocytes against the body by their fixed ends until the cells disappeared. Crookshank, on the other hand, was unable to satisfy himself that they attack the red blood cells.

Laveran and Mesnil do not consider anæmia sufficient to account for the death of animals. They say that the manner in which the parasites act is still unknown.

There is certainly something very curious about the presence of anæmia in this disease and in the action of the parasites in producing it, as well as bringing about death. The mechanical destruction of the red blood cells is not of the importance many writers attach to it. It seems to us that there is some factor in addition to mechanical action, which causes such profound changes, and strong evidence in favor of this is found in the peculiarity of the gelatinous deposits. The parasites appear in some manner to produce, or cause some part of the animal economy to liberate, this peculiar substance, which is not a simple infiltration of fatty tissue, but is of a different character. The deposit undoubtedly is formed gradually, as is inferred from the slow change in the secretions. The discharges from the nose and eyes, at first watery, gradually take on the same character, and before death become very tenacious and solidified in the nose and corners of the eyes.

Referring to the action of *Trypanosoma* in the animal economy Laveran and Mesnil state:

"Evidently, in the presence of an infection so intense as that which is shown at the moment of death of rats, mice, and other animals, the mechanical action of such a number of parasites is to be considered. This alone, however, in our opinion does not suffice to explain the cause of death. Rats infected with *Tr. lewisii* may have a great number of parasites and yet feel no inconvenience. In certain attempts at treatment, of which we shall speak later, a rat has had for more than fifteen days as many parasites in the blood as red cells.

"One is led to think of a toxic action of the parasites and of the intervention of the soluble products excreted by them. The observations of the course of the disease in rabbits, guinea pigs, and cows, in which the parasites are not so large as in other animals, even at the time of death, and the profound dejection of certain animals when infected, as the ass, plainly corroborate this view."

Strong reported: "Large amounts of blood taken from monkeys suffering with experimentally produced trypanosomiasis of severe type were passed through a Berkefeld filter and the filtrate injected into other monkeys. No symptoms of trypanosomiasis were produced. Large celloiden capsules containing blood with many parasites were placed in the abdominal cavities of sheep, but the results were also negative."

All attemps to isolate a toxin have proved futile. It does not seem to us that a toxin can enter into consideration; but, as has already been said, the character of the action which results in the formation of the peculiar gelatinous deposits will probably lead to a solution of the problem.

Voges believes that in mal de caderas death usually results from a gradually progressive heart failure, and in some cases occurs suddenly from the same cause. He says that death usually comes on with a fall of the temperature, rarely at its height.

This statement is true, but does not go far enough; an explanation of the cause of heart failure is what is desired. The condition described above may offer some solution, in that the gelatinous deposits are often abundant around the heart, and a microscopic tissue shows that a similar condition is present in the myocardium.

The incubation period of the disease in different animals has an important bearing upon the application of methods for the control of epidemics. It will be discussed in detail as the study of the disease in different animals is taken up. The evidence of previous workers and our own observations show that it varies with the manner of inoculation as well as with other conditions.

In all the forms of trypanosomiasis the infection seems to involve particularly the genitalia, the skin, and the organs of special sense. The skin symptoms consist in a roughening of the hair, which also falls out in places, a thickening of the epidermis, often with exfoliation, and in some stages of the disease various skin eruptions. These may be simple erythema, and more rarely they may assume the severer forms, as urticaria, or in extreme cases a distinct localized ulceration may occur. The scrotum and penis in the male and the vulva in the female are often swollen, and ulcerations of the penis or vulva are frequent symptoms, especially in dourine.

TRYPANOSOMIASIS OF HORSES.

We shall begin the discussion of trypanosomiasis in the different species of animal with that of the horse, which, from an economic standpoint, is the most important animal naturally susceptible to the disease in the Philippine Islands.

Most of the writings relating to trypanosomiasis deal particularly with the infection in equines, and as a consequence literature is rich in descriptions which in many points can not be improved upon. It is our intention briefly to review the most important writings on surra, nagana, dourine, and mal de caderas in each species of animal, following this with our own observations, and finally, when through with the species discussed, to devote a chapter to the discussion of the individuality of these diseases.

Surra, according to Lingard, manifests itself, after a period of incubation, in fever, a stumbling gait, and general or localized eruptions, with the presence of *Trypanosoma*

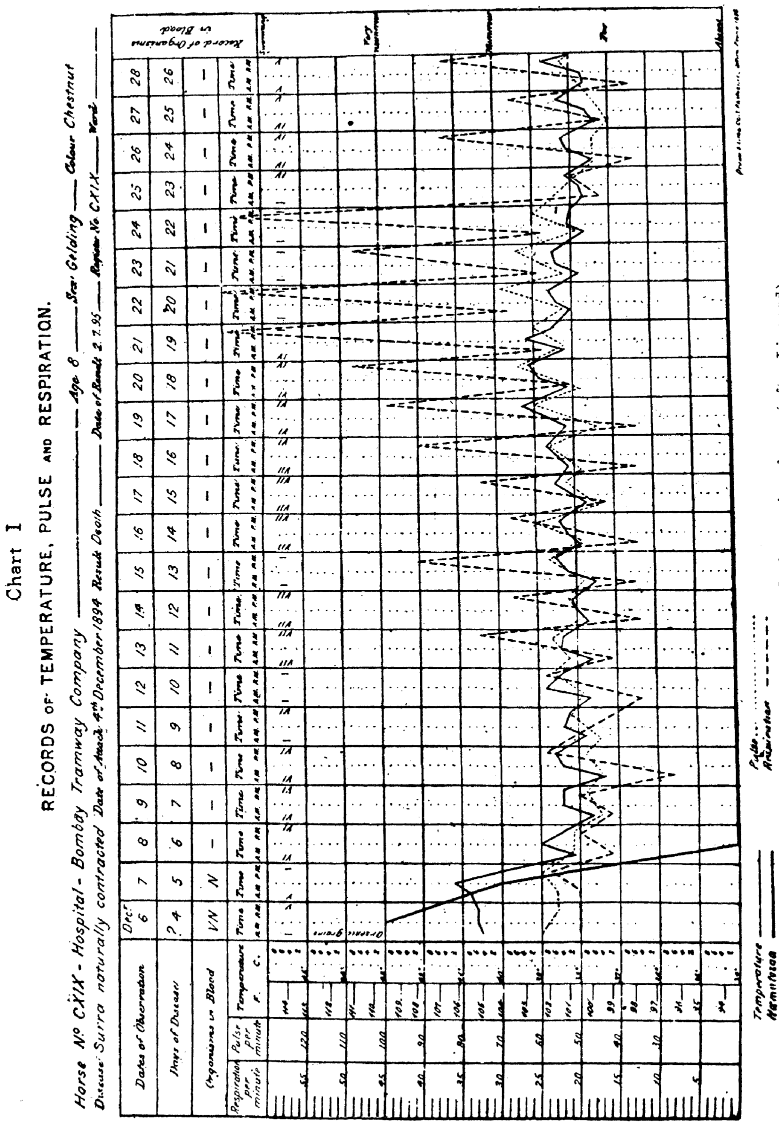


FIG. 107.—Temperature record of surra in a horse (after Lingard).

SURRA

Chart II.

RECORDS OF TEMPERATURE, PULSE AND RESPIRATION.

Horse No. CXIX ——— Age 8 ——— Sex Gelding ——— Colour Chestnut ———

Disease Surra Naturally contracted ——— Date of Attack ——— Result ——— Date of Result ——— Register No. CXIX ——— Ward ———

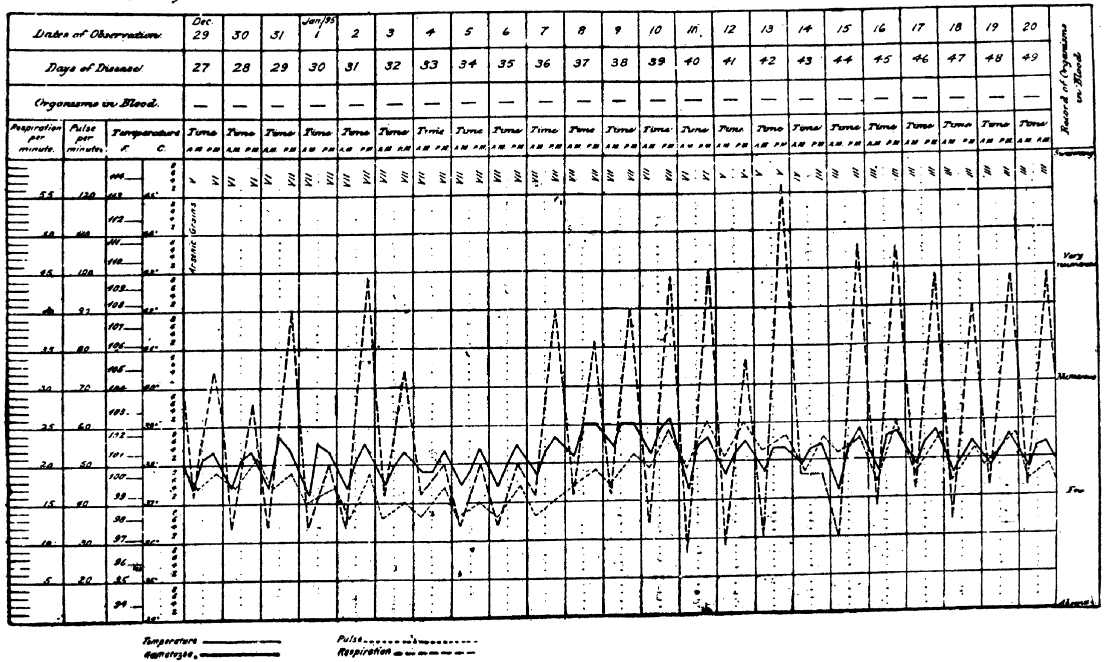


FIG. 107—Continued.

Chart III.

RECORDS OF TEMPERATURE, PULSE AND RESPIRATION.

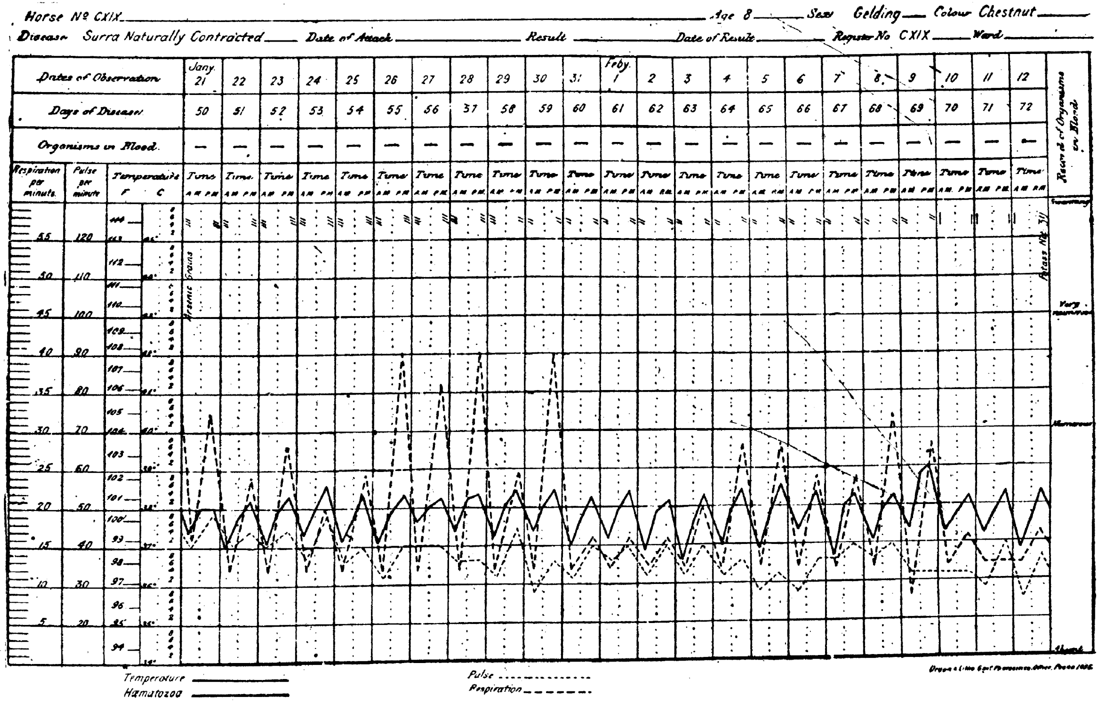


FIG. 107—Continued.

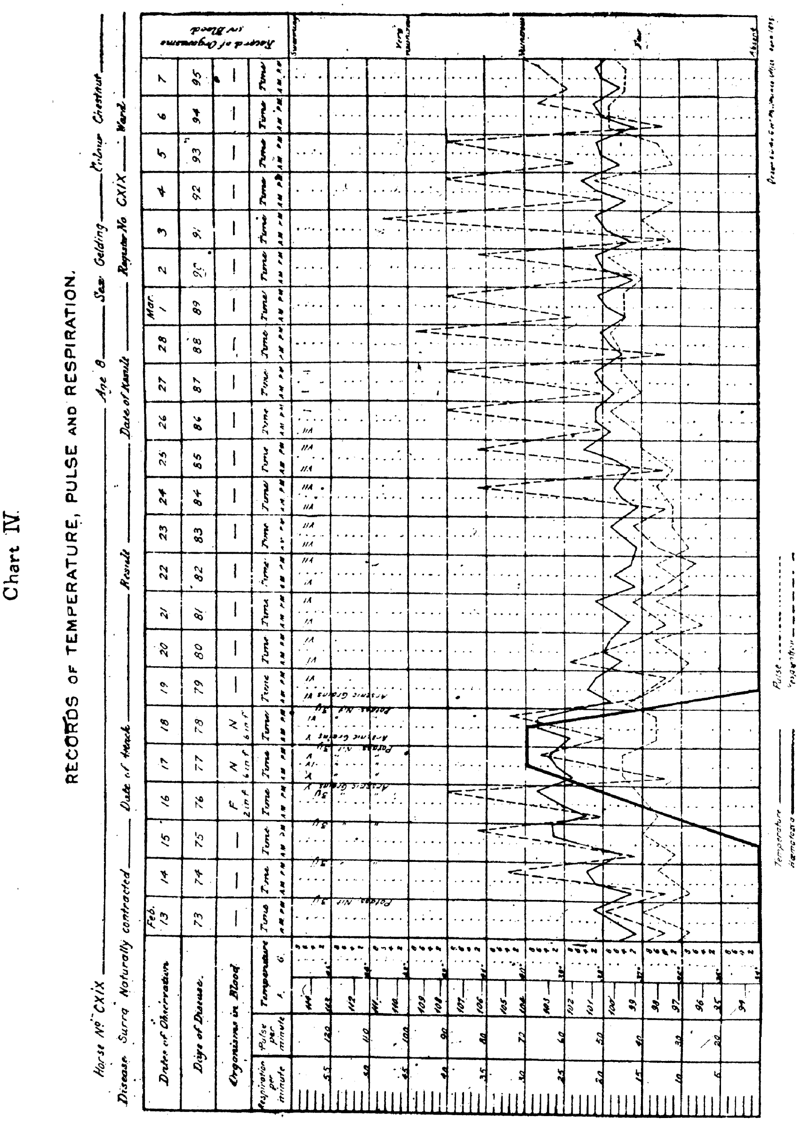


FIG. 107—Continued.

Chart V.

RECORDS OF TEMPERATURE, PULSE AND RESPIRATION.

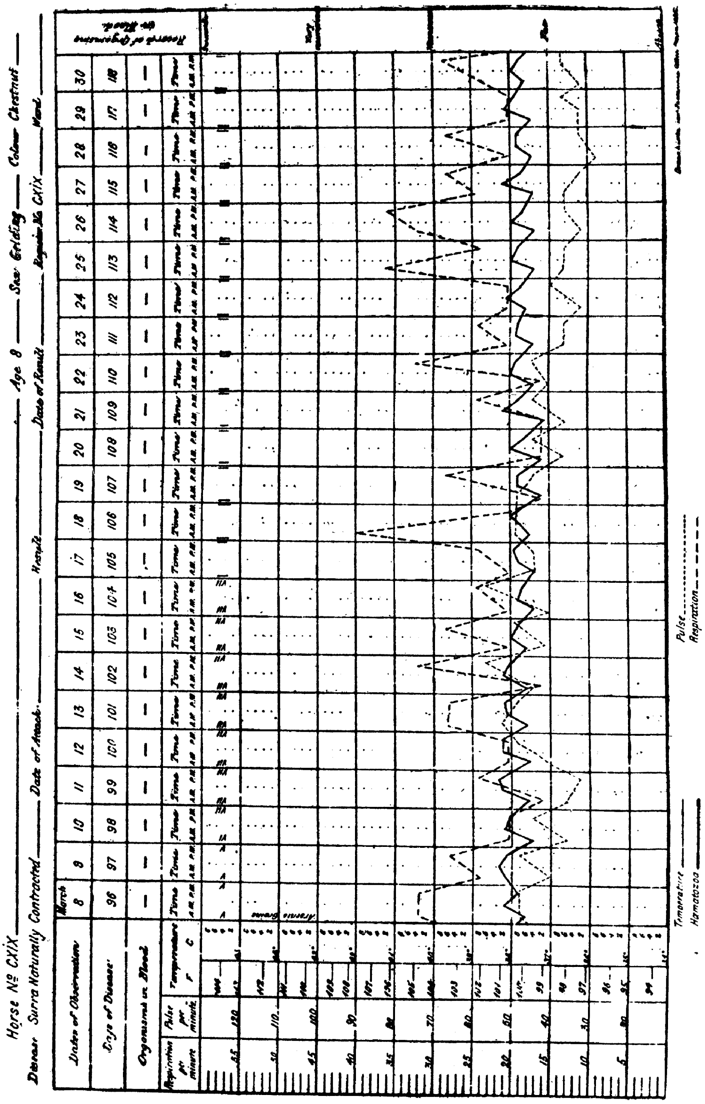


FIG. 107.—Continued.

SURRA

Chart. VI.

RECORDS OF TEMPERATURE, PULSE AND RESPIRATION.

Horse No CXIX Age 8 Sex Gelding Colour Chestnut
Disease Surra Naturally contracted Date of Attack Result Date of Result Register No CXIX Ward

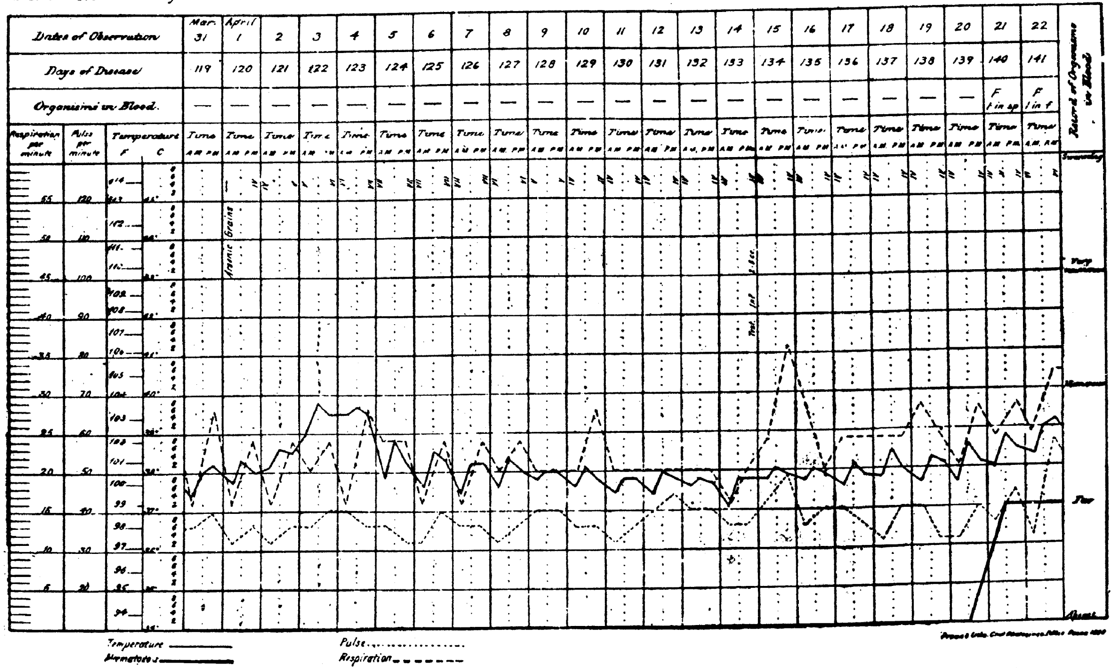


FIG. 107.—Continued.

SURRA

Chart VII

RECORDS OF TEMPERATURE, PULSE AND RESPIRATION.

Horse Nº CXIX Age 8 Sex Gelding Colour Chestnut

Disease Surra Naturally Contracted Date of Attack {Organism first looked for and found 4th Dec. 1894} Result Date of Result Register No CXIX Ward

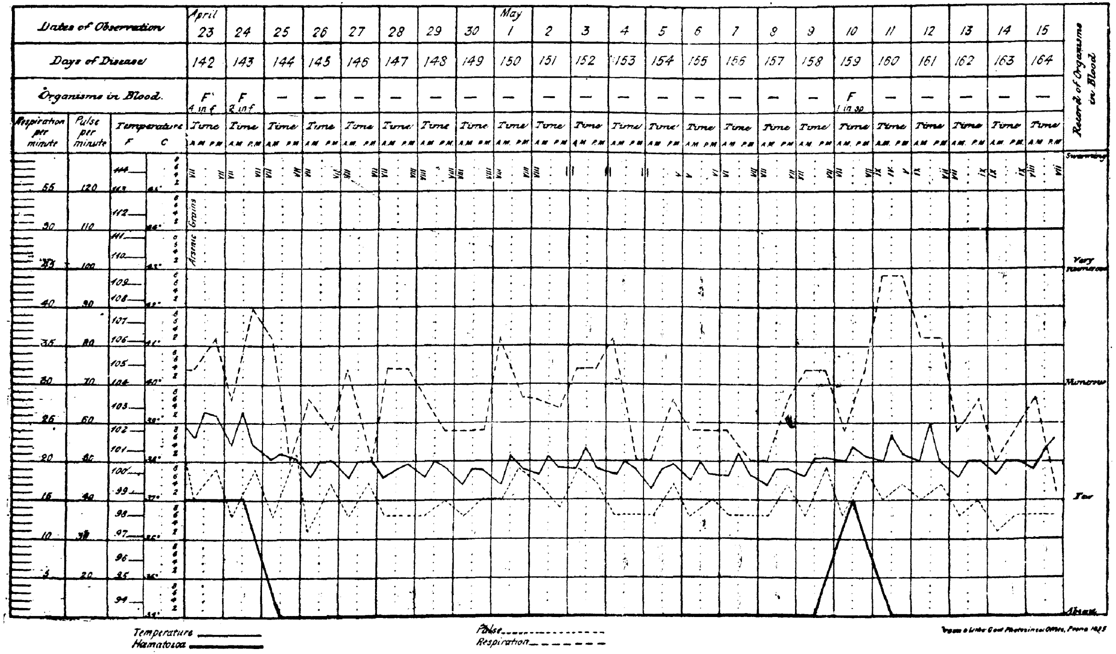


FIG. 107—Continued.

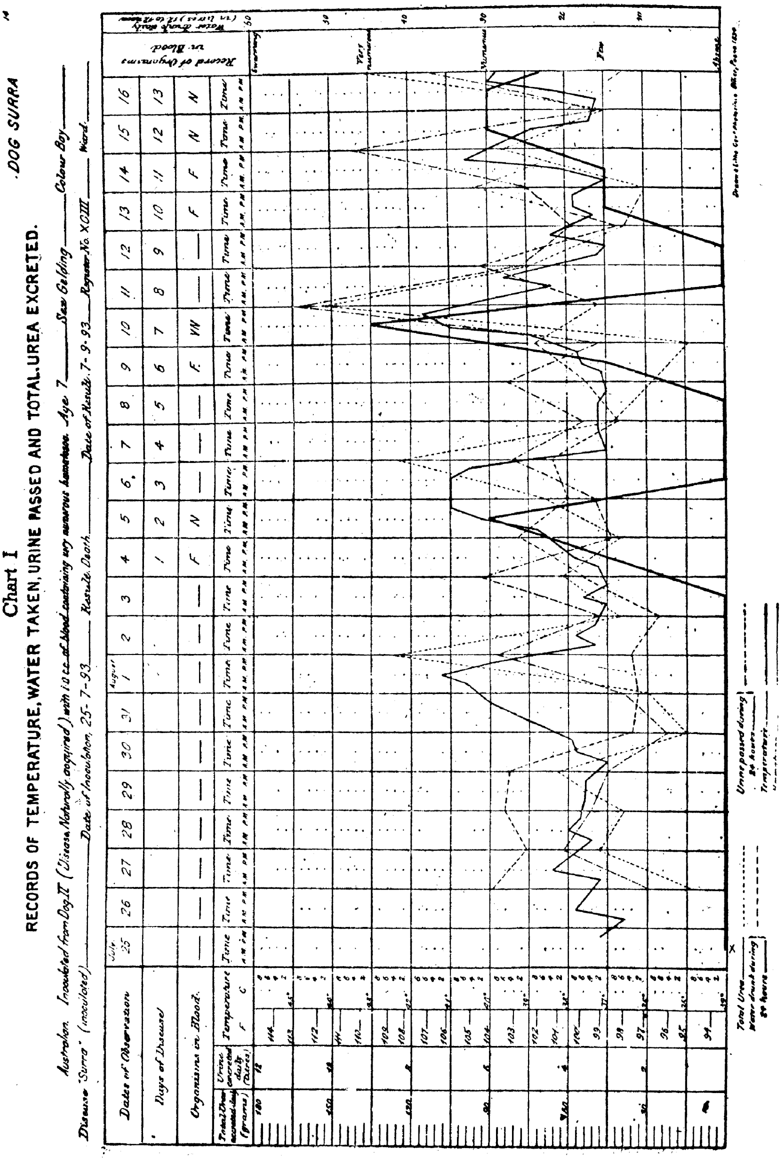


FIG. 108.—Temperature record of surra in a horse (after Lingard).

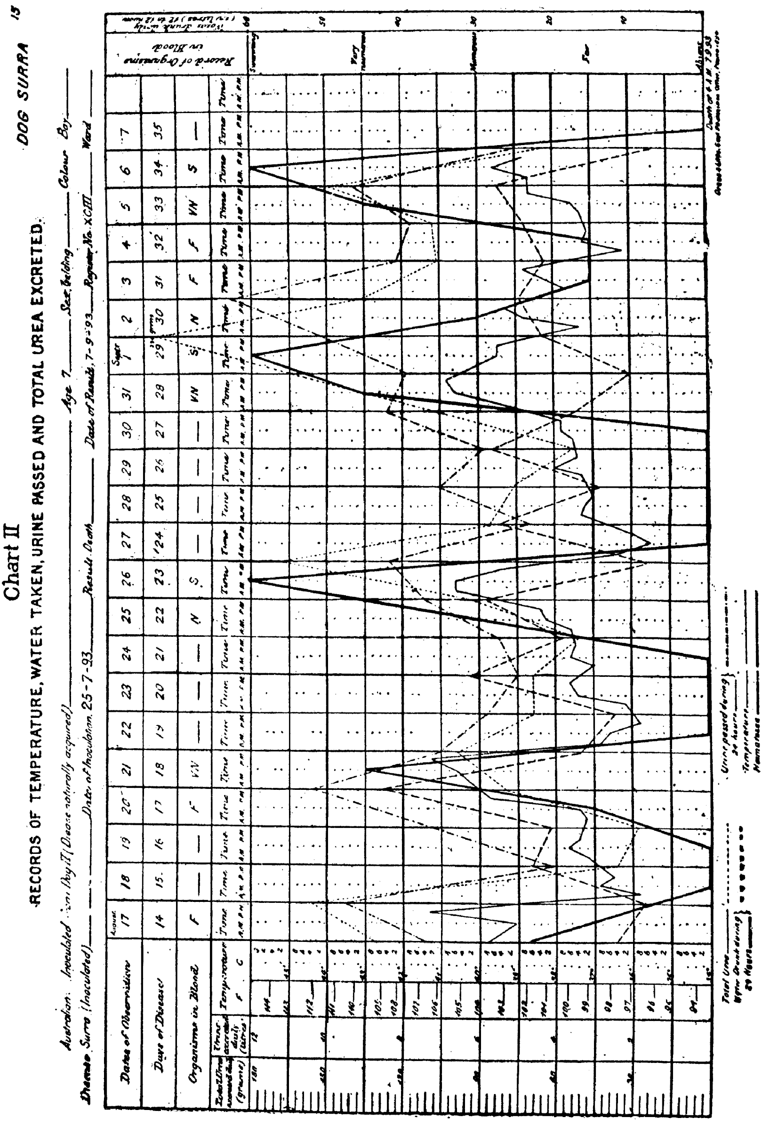


FIG. 108—Continued.

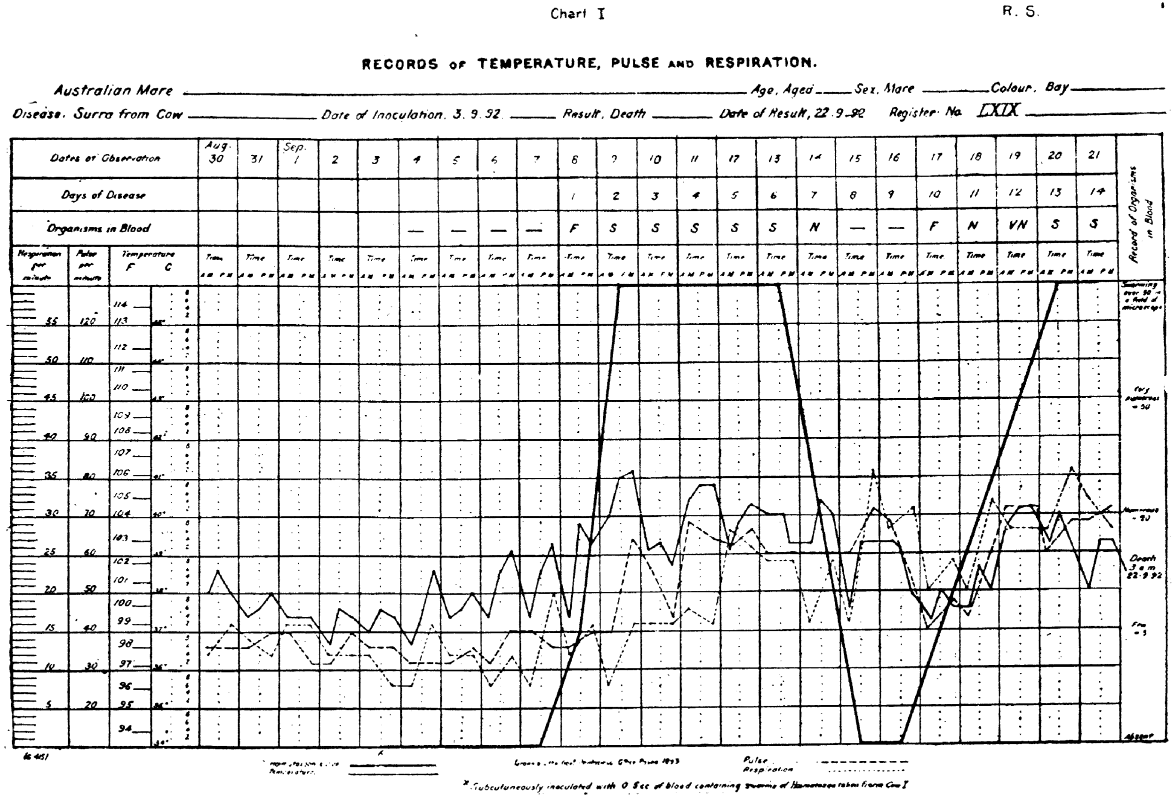


FIG. 109.—Temperature record of surra in a horse (after Lingard).

in the blood. A period of apyrexia may here supervene, lasting for a day or so, during which the animal appears better. These apyrexial periods may occur a number of times during the course of the disease. In every instance, however, they are followed by a fever, usually from 38.7° to 40° C., thirst, slight loss of appetite, ecchymoses of the conjunctivæ, with increased lachrymation, and mucous discharge from the nostrils. The submaxillary glands may be enlarged, and œdema beginning on the legs or sheath may develop. Emaciation is rapid and progressive. With each exacerbation of fever the other symptoms become intensified and the animal is made weaker. The œdema spreads, the mucous surfaces become very pale and tinged with yellow, and the respiration is quickened. The appetite remains good. Toward the end paresis of the hind quarters becomes noticeable. Paralysis of the sphincter ani is frequent. Shortly before the end the heart's action in many cases becomes violent, and death may result suddenly from heart failure. When this does not occur, the animal finally falls to the ground and dies from exhaustion.

Nagana is carefully described by Bruce, who gives as the principal symptoms, fever of a remittent or intermittent type; catarrhal secretions from the nose and eyes; staring of the coat; and œdema of the abdominal region, the prepuce, and the posterior extremities. The animal becomes markedly emaciated and has a dejected appearance, the head hangs, the hair becomes very rough and in places falls out, the mucous membranes of the eyes and genitals become very pale, and there is generally a slight opacity of the cornea. Just before death the animal falls to the ground and dies, apparently without suffering.

Kanthuck, Durham, and Blanford inoculated two horses, one of which, a well-fed Russian cart horse, lived seven weeks, and the other eight days. Wasting was very conspicuous. The period of incubation was followed by a smart rise in temperature and by the appearance of parasites in the circulating blood. A sudden rise of temperature immediately followed each increase in the number of parasites in the blood. At the time of death there was marked fever.

Laveran and Mesnil report two cases, as follows: The first symptoms were the appearance of parasites in the blood, and fever. One of the horses, which was not in a good condition at the time of inoculation, died in sixteen days; the other in forty-three days. With one or two exceptions parasites were always found in the blood by microscopic examination. The red blood cells gradually diminished and at death were reduced to half their original number, or even less. Parasites appeared in the blood in less than four days after subcutaneous inoculation, and their appearance was coincident with the first rise in temperature, which in a few days reached 41.4° C. This was followed by a drop to 38° C., and a corresponding reduction of the number of parasites in the circulation. With the second rise of tempereture to 40° C., where it remained oscillating between 38° and 40° C. until the day of death, the parasites again became numerous and remained so throughout the disease. Beginning about the fifteenth day after inoculation, there was œdema of the penis, gradually involving the belly, but not the posterior extremities. Lesions of the nose and eyes were not noticed. The appetite, except at the height of the fever, was good. There was no apparent emaciation and no serious loss of weight.

During the incubation period of mal de caderas, according to Voges, no symptoms are noticed, but as the disease progresses the animal becomes inactive and heedless of what is going on about it. It allows the head to drop carelessly, and the whole body loses its firmness and becomes more and more sluggish. On being ordered it responds very lazily, and "even the wildest and meanest horses no longer balk and bite." At this period of the disease the animal may fall to the ground and die suddenly. On the other hand, if assisted to rise it may live for as much as two weeks.

Following the incubation period, which varies in duration, the temperature rises rapidly, often to 40° and 41° C., and on the following day falls to normal or nearly so. It then goes up again, and within five days reaches 40° C. or more. The period of apyrexia between these elevations is of uncertain length. This Voges calls the first stage of the disease, the important symptom being the intermittent fever.

In the second stage the fever is prominent, but the intermissions become less marked as the disease advances, the temperature varying from 38.5° to 39.8° C.

Before death great variations, sometimes from 34° to 39° C. from morning until evening, may occur, the curve being as irregular as a septic one.

Hemoglobinuria may occur temporarily in the first stage of the disease. Red blood cells are usually present in the stools, which as a rule are normal in consistency and number, but in rare instances may be covered with a mixture of coagulated blood. Thirst increases and becomes marked as the disease progresses. The pulse is at first normal, but the heart grows weaker with the course of the illness, finally allowing the œdema which is seen in the later stages. Sudden death from heart failure sometimes occurs.

Animals with mal de caderas show no evidence of pain. During the first stage the reflexes are normal, but even as early as this there may be a diminished sensibility, which later on becomes marked, so much so that animals pay no attention to swarms of flies. Incoordination affecting particularly the hind parts becomes so severe that the animal reels as if drunk.

The hair remains smooth and glossy during the first stage, and shedding, if present, is normal. In the second stage it loses its gloss and lies less smooth. Emaciation is not noticeable during the early part of the disease, and with good food animals often gain in weight; but during the later periods this symptom is marked and the loss may reach 100 kilos or more before death. The appetite, as a rule, is not disturbed, but continues good to the end, and in some cases it is noticeably increased.

Dourine is a recognized form of trypanosomiasis in horses, but clinical descriptions are not so complete as for the other types. It is usually referred to as resembling one of the other forms. The emphasized symptoms, in addition to the ones already given, consist in phlegmanous ulcers of the genitalia and to a less extent of various parts of the skin. The temperature, as a rule, does not run so high in this form of the disease as in the others, and parasites are much less numerous in the peripheral circulation. On the whole, the course is considered more chronic than that of surra and the variety of susceptible animals is smaller.

As to the general description of the symptomatology of the disease as observed in the Philippines, we have nothing to add to the classical ones of the various writers in India, South America, and Africa.

With the ultimate object of discovering methods of prevention and cure, toward which all of our work is directed, one of the most important questions to decide and one which so far has not been definitely determined is the incubation period in naturally contracted cases. Authors writing of the disease under the same and different names give for it various lengths of time, and not a few say that it is unknown.

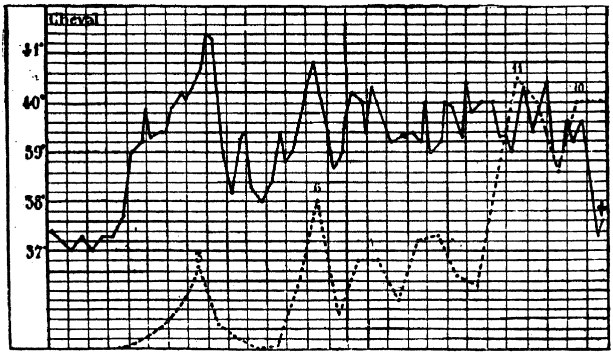


FIG. 110.—Nagana in a horse (——) temperature, (....) *Trypanosoma*. (After Laveran and Mesnil, 1902, fig. 4.)

Evans fed two horses 20 ounces each of surra-infected blood, obtaining positive results and an incubation period of six days. He did not prove his animals free from infection at the time of feeding, does not state that biting insects were excluded, and of course can not say that there were no lesions in the mouth.

Lingard fed a horse frequently with small quantities of infected blood well diluted in water, with an incubation period of one hundred and thirty days or less, depending upon which feeding produced the infection. To another horse he fed 200 minims of infected blood in a similar manner, the incubation period being, according to the author, seventy-five days. These experiments are open to the same criticism as those of Evans.

Subcutaneous injection.—In twelve horses inoculated subcutaneously by Lingard, the average incubation period was five and two-thirds days, the longest being eight days following the injection of 1 cubic centimeter of blood containing but few *Trypanosoma*, and the shortest four days, which occurred in four of the horses after the inoculation of 1 to 3 c. c. of blood containing *Trypanosoma* in large numbers. In three horses injected subcutaneously with blood taken during the intermissions of the disease and microscopically free from parasites the average incubation period was eight and two-thirds days, the longest being ten days and the shortest four. In

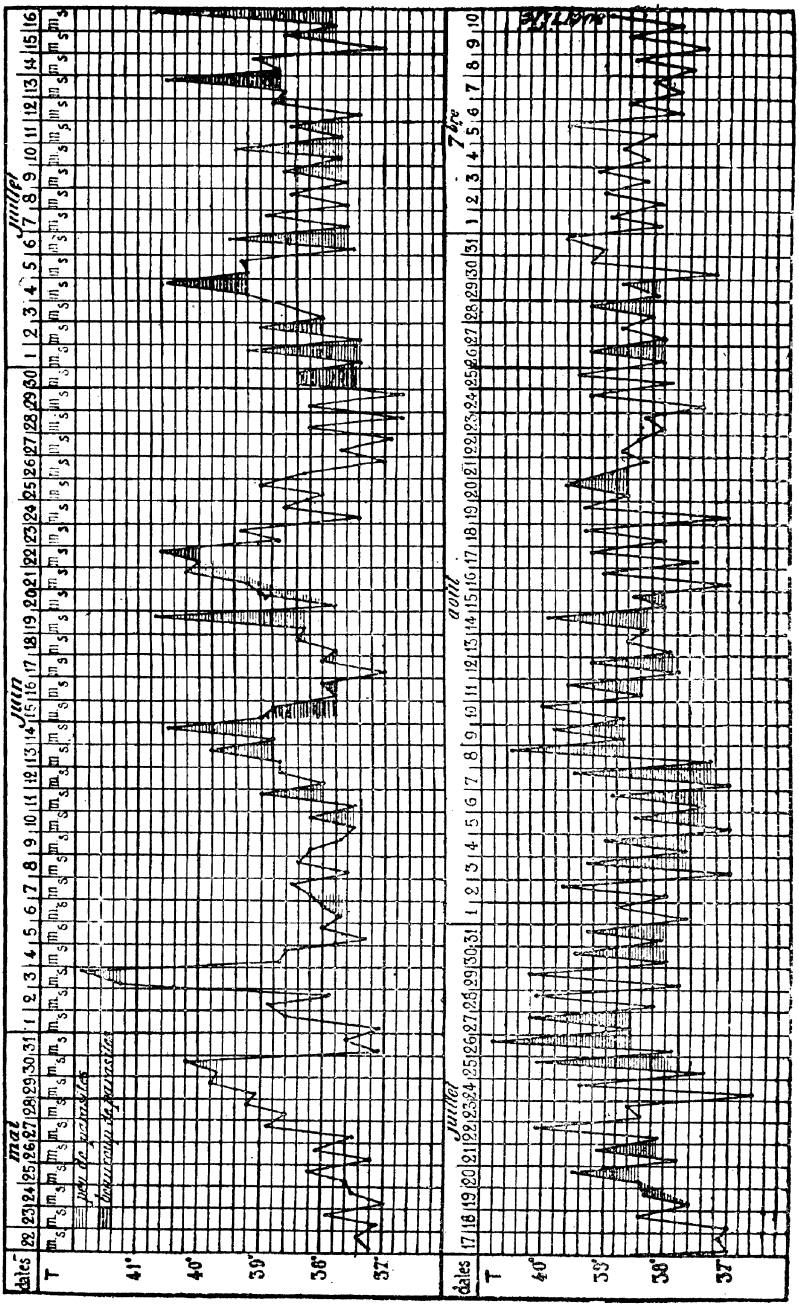


FIG. 111.—Temperature and its relation to the number of parasites in the peripheral circulation in "surra americain." (After Lignières, 1903, fig. 10.)

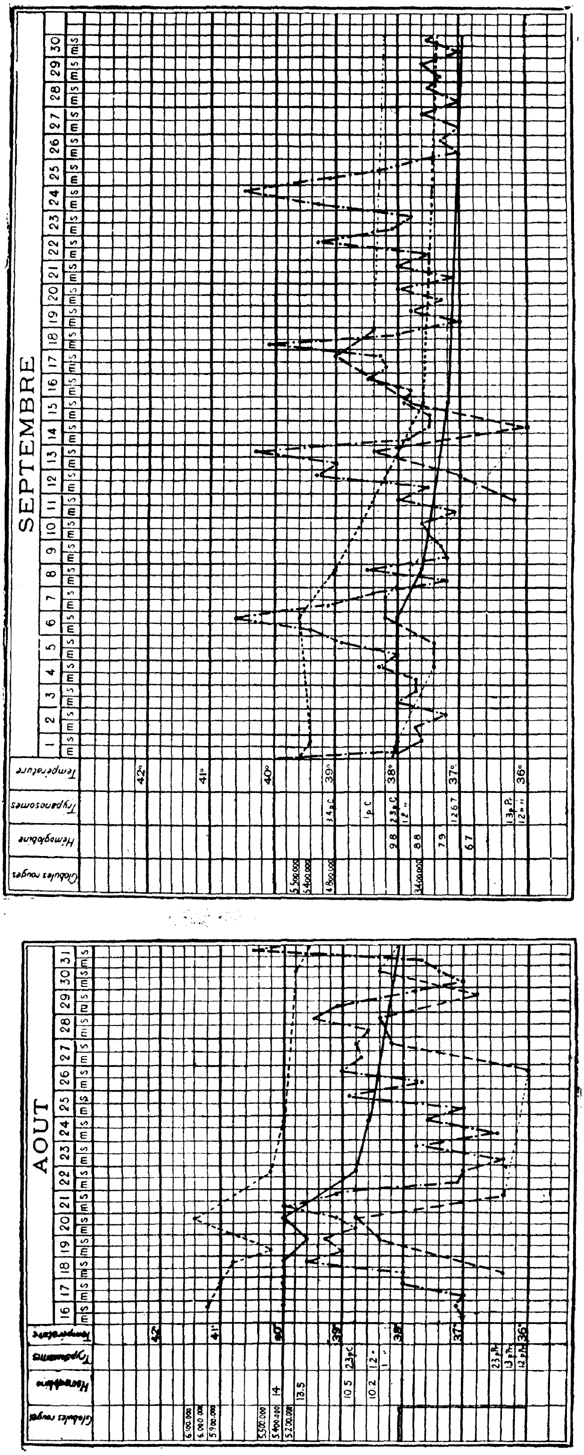
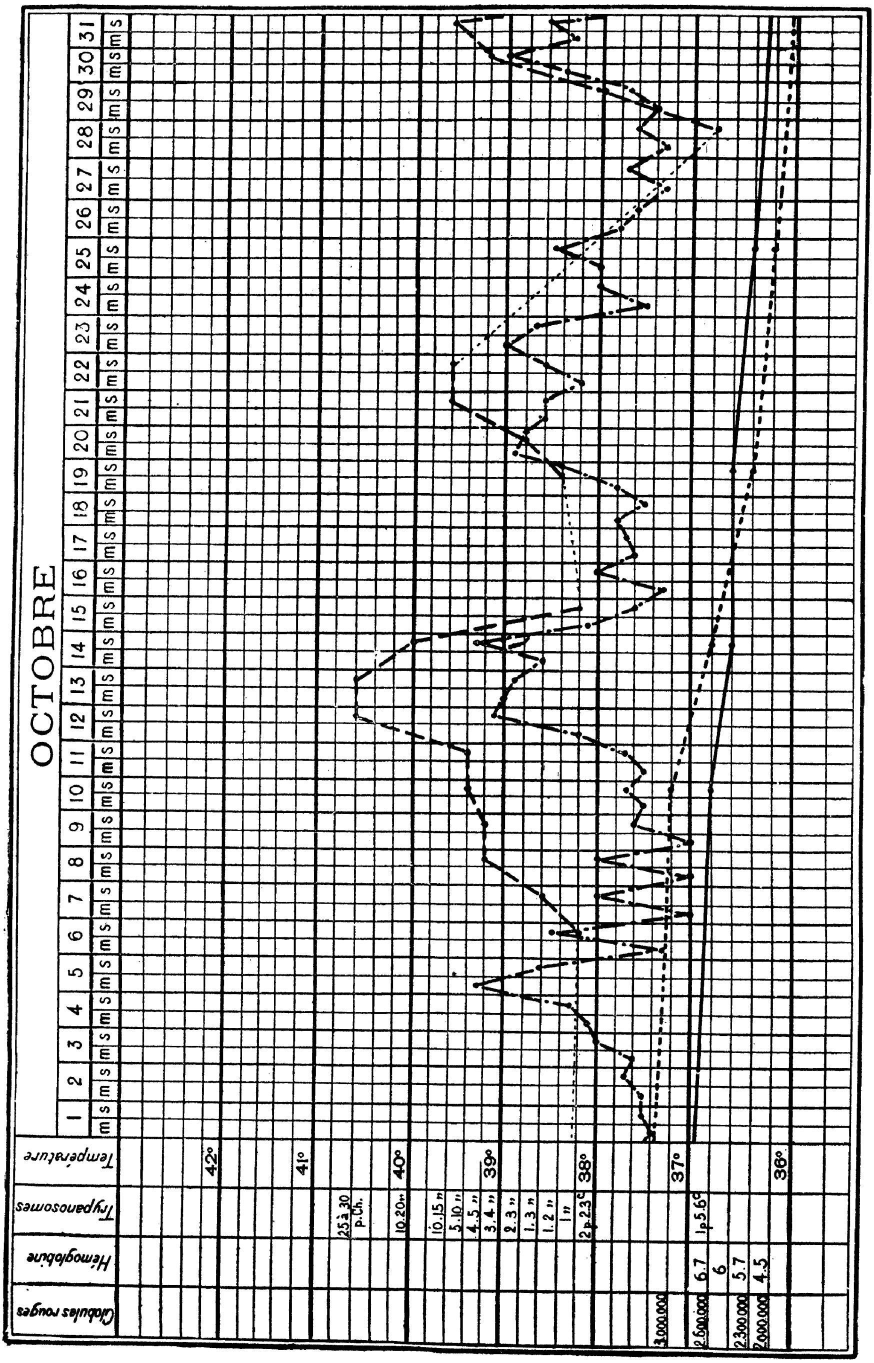
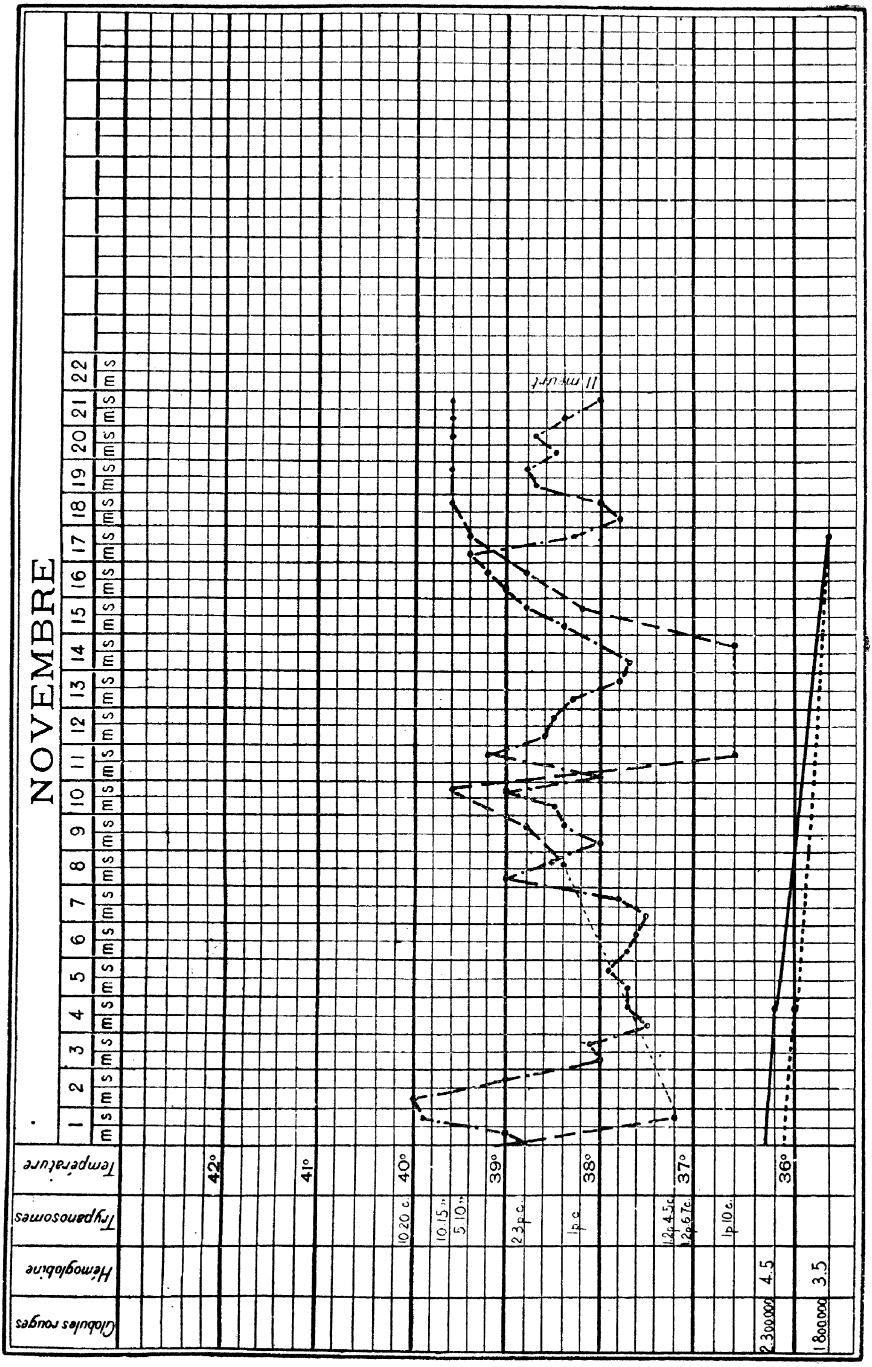


Fig. 114.—"Surra americain" in a horse. (After Sivori and Lecler, 1902.)


OCTOBRE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
m s
Temperature
Trypanosomes
Hémoglobine
Globules rouges
42°
41°
40°
39°
38°
37°
36°
25 à 30 p.Ch.
10.20 „
10.15 „
5.10 „
4.5 „
3.4 „
2.3 „
1.3 „
1.2 „
1 „
2 p.2.3 C
1 p.5.6 C
6.7
6
5.7
4.5
3.000.000
2.600.000
2.300.000
2.000.000


NOVEMBRE
1
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22
m s
Température
Trypanosomes
Hémoglobine
Globules rouges
42°
41°
40°
39°
38°
37°
36°
10 20 c.
10.15 „
5.10 „
2 3 p.c.
1 p.c.
1 2 p 4.5 c.
1 2 p 6.7 c.
1 p 10 c.
4.5
3.5
2.300000
1.800000
Il meurt

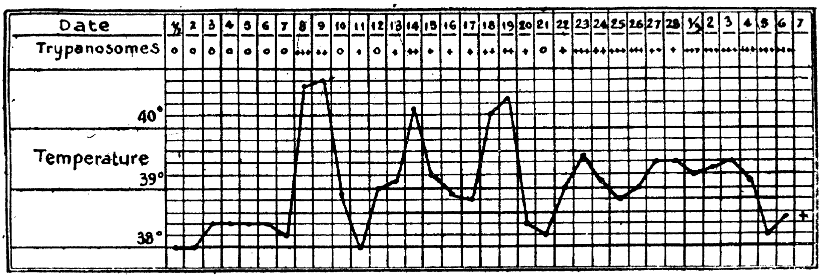


FIG. 112.—Temperature chart of a horse following intravenous injection of 20 c. c. of blood obtained from a horse which showed no parasites in the blood. Dead in thirty-four days. (After Lignieres, in Recueil d. Med. Vet. vol. 10, No. 4, Feb. 28, 1903, p. 117.)

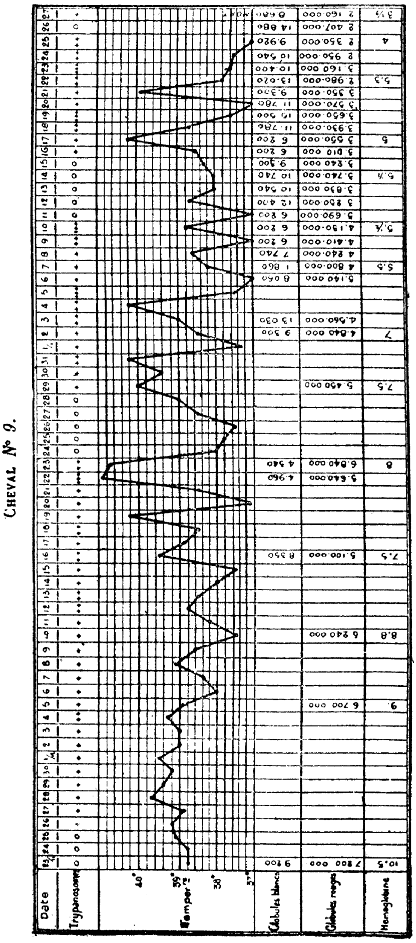


FIG. 113.—Temberature record of a horse inoculated intracerebrally with Trypanosoma from a dead rat. (After Lignieres, 1903.)

twelve horses inoculated subcutaneously with blood taken one and one-half to sixteen hours post-mortem, the average incubation period was nine and one-half days, the longest being thirteen days following the injection of 2 c. c. taken one and one-half hours host-mortem, and the shortest six days in a case of inoculation with 6 c. c. of blood taken one and one-half hours post-mortem.

In two cases of subcutaneous injection of 1 and 2 c. c. of serum taken forty-five minutes and two hours, respectively, post-mortem, from a horse dead of the disease, the incubation periods were eight and nine days. A horse injected subcutaneously with 1 c. c. of blood from the tunica vaginalis of a goat suffering from the disease developed an incubation period of five days, and a horse inoculated with 1 c. c. of the blood of the same goat had one of thirteen days.

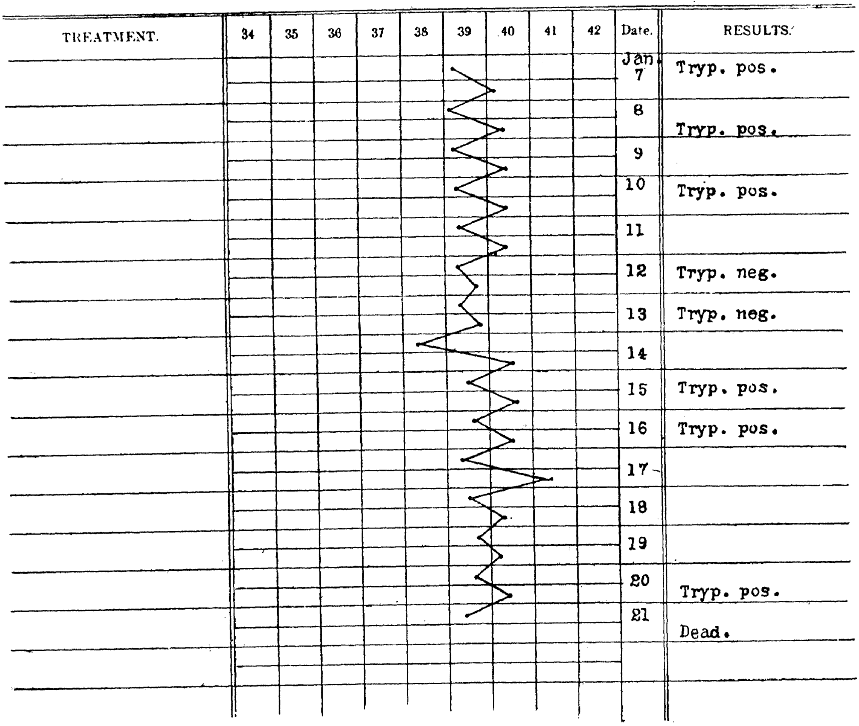
BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Horse *No* 147
January 7, *190*3

Weight 700 lbs. *Age* 8 yrs. *Sex* Male *Color* Bay *Inoculation* Received with surra.

History Bay native pony in good condition.



Date.	RESULTS.
Jan. 7	Tryp. pos.
8	Tryp. pos.
9	
10	Tryp. pos.
11	
12	Tryp. neg.
13	Tryp. neg.
14	
15	Tryp. pos.
16	Tryp. pos.
17	
18	
19	
20	Tryp. pos.
21	Dead.

FIG. 115.—Temperature record of surra in a horse.

There are numerous observations to show that the incubation period in naturally contracted cases does not vary more than in experimental cases. It is usually from four to seven days, although in exceptional cases it may be more. In one of our animals, in which the evidence was complete, it was eleven days.

The incubation period in horses artificially infected by us varied somewhat with the condition of the animal, the place of inoculation, the character of the infecting material, and perhaps with other causes; but from observation we are certain that variations in naturally contracted cases are not greater and that they occur within comparatively small limits, in most cases from four to seven days. One of our horses had an incubation period of eleven days, and another, which was suffering with a malignant growth and a temperature of 39.5° to 41° C., had one of eighteen days following a subcutaneous injection. As already stated, we are convinced that the naturally contracted disease does not differ from that produced by inoculation in the length of its incubation period, its symptoms, or any other respect.

Fever is one of the most important symptoms and is the first clinical evidence of infection. It can usually be determined during the incubation period in exposed animals. The temperature as a rule rises very rapidly, and during the first few days may reach 40° to 41° C., after which it becomes irregularly intermittent, remittent, or, in rare instances, relapsing in type, always being highest in the afternoon.

BUREAU OF GOVERNMENT LABORATORIES.

BIOLOGICAL LABORATORY.

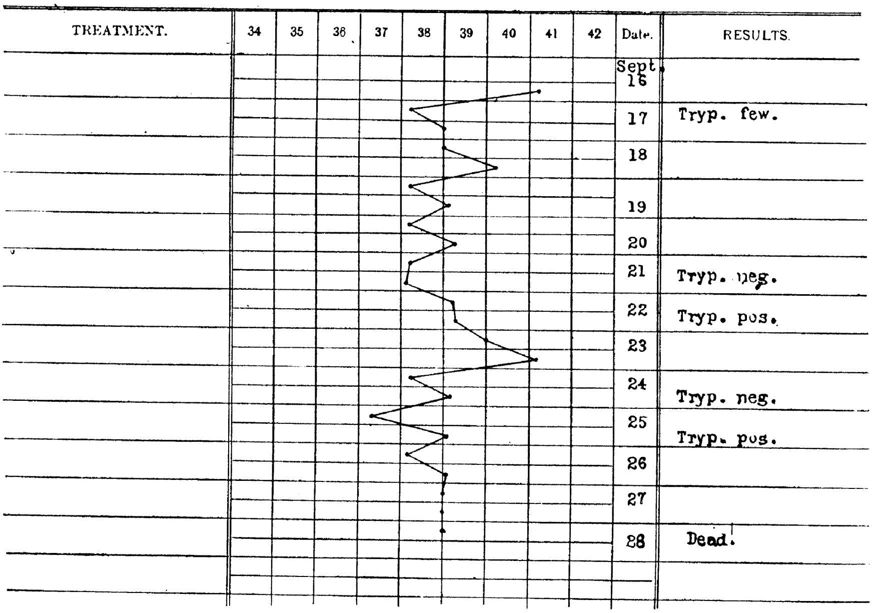
ANIMAL RECORD.

Horse *No* 50

September 16, *190* 2

Weight 450 lbs. *Age* 3 yrs. *Sex* Male *Color* ______ *Inoculation* Received with surra.

History Native pony, emaciated, hair ruffled, enormous edematous distention of penis, from which lymph is exuding. Numerous parasites in the blood.



TREATMENT.	Date.	RESULTS.
	Sept. 16	
	17	Tryp. few.
	18	
	19	
	20	
	21	Tryp. neg.
	22	Tryp. pos.
	23	
	24	Tryp. neg.
	25	Tryp. pos.
	26	
	27	
	28	Dead!

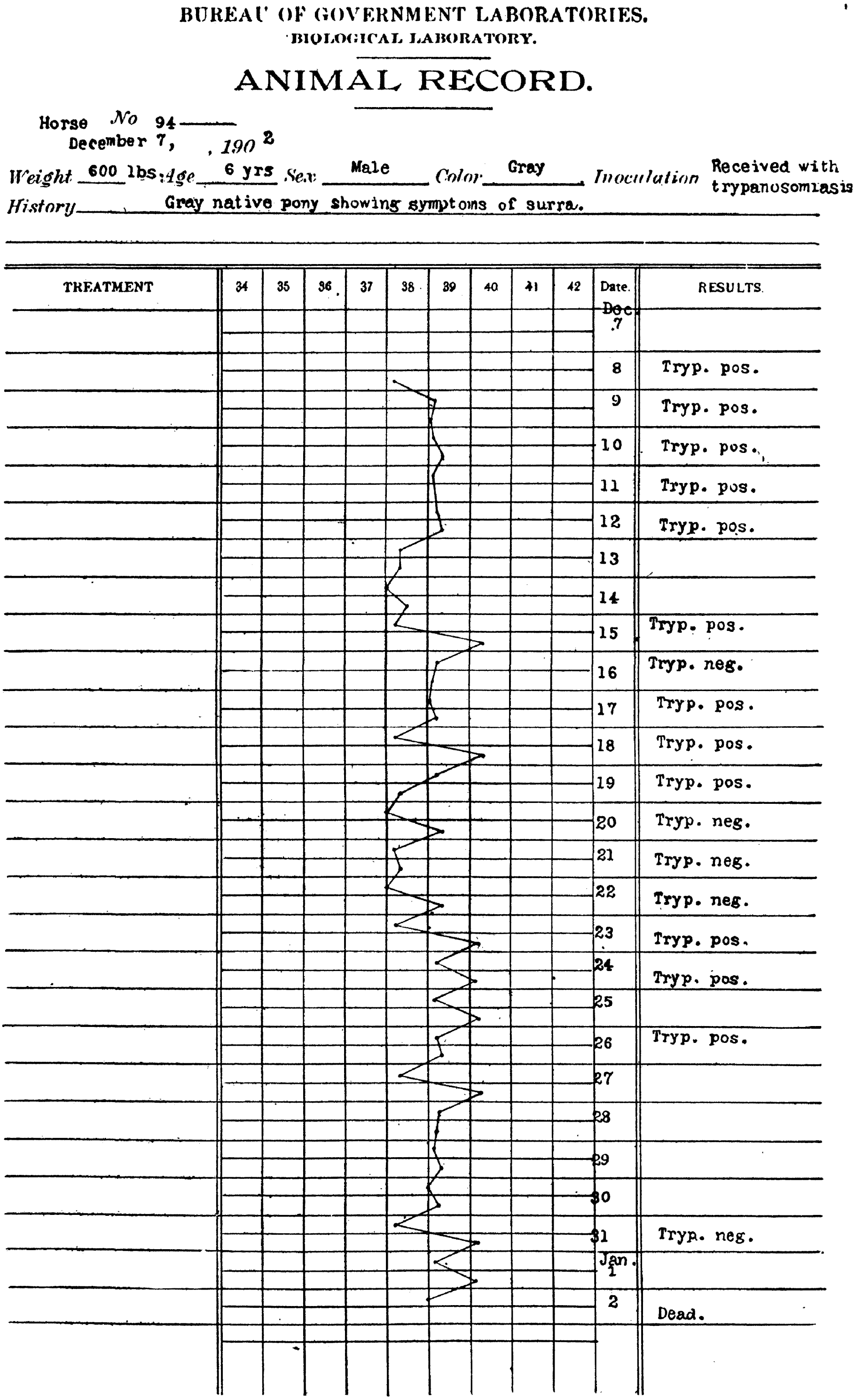
FIG. 116.—Temperature record of surra in a horse.

The especial value of the temperature in diagnosis is its mere presence in connection with other symptoms. There is at any time very little in its variations which is characteristic enough to be very significant, but taken over a long period, its course, while not constant, makes a suggestive picture.

The illustrations (see figs. 101–104, 115–118) give an idea of the course of the fever in horses in Manila.

Simple observations of a horse suffering with this disease do not afford sufficiently exact data during the very early stages, but as the disease progresses they become of the greatest diagnostic value.

The hair, at first normal, soon becomes rough and shows a tendency to fall out in places, especially the long hairs around the nose and eyes, though this never progresses to the same extent as it is seen to do in some of the smaller animals. The skin becomes dry and scrawny and sometimes shows eruptions in places, which may



BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Horse *No* 94
December 7, *190*2

Weight 600 lbs. *Age* 6 yrs *Sex* Male *Color* Gray *Inoculation* Received with trypanosomiasis

History Gray native pony showing symptoms of surra.

TREATMENT	Date.	RESULTS.
	Dec. 7	
	8	Tryp. pos.
	9	Tryp. pos.
	10	Tryp. pos.
	11	Tryp. pos.
	12	Tryp. pos.
	13	
	14	
	15	Tryp. pos.
	16	Tryp. neg.
	17	Tryp. pos.
	18	Tryp. pos.
	19	Tryp. pos.
	20	Tryp. neg.
	21	Tryp. neg.
	22	Tryp. neg.
	23	Tryp. pos.
	24	Tryp. pos.
	25	
	26	Tryp. pos.
	27	
	28	
	29	
	30	
	31	Tryp. neg.
	Jan. 1	
	2	Dead.

FIG. 117.—Temperature record of surra in a horse.

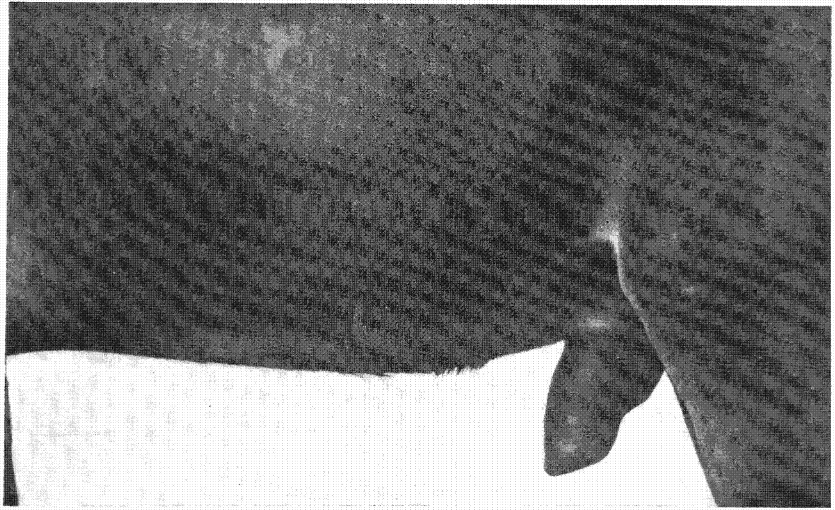


FIG. 120.—SHOWING URTICARIAL ERUPTION AND EDEMA.

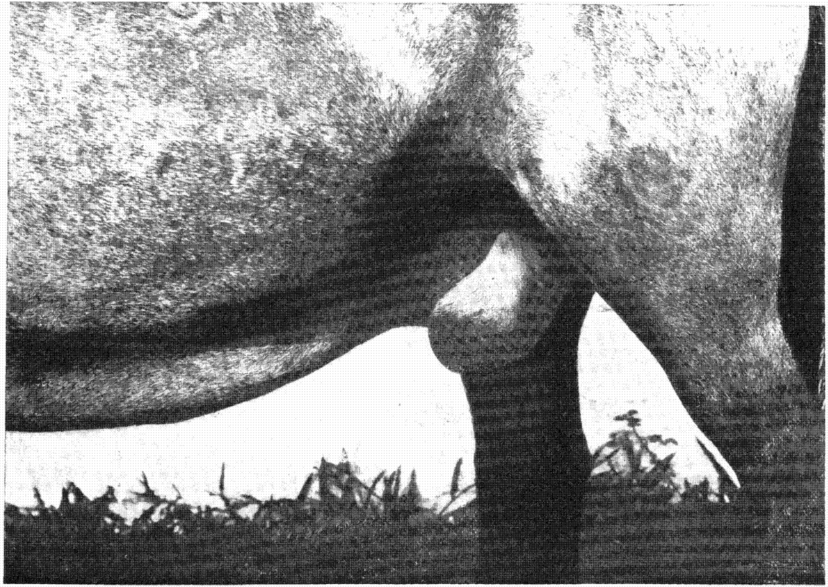


FIG. 121.—SHOWING EDEMA OF SCROTUM AND BELLY.

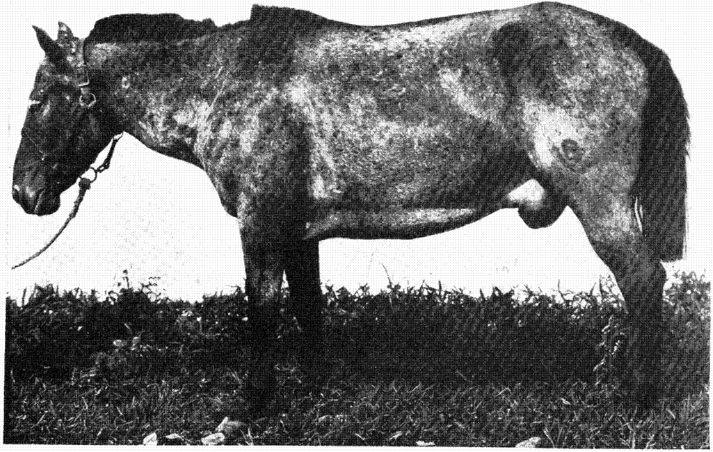


FIG. 122.—NATIVE PONY WITH SURRA, SHOWING EDEMA AND CONDITION OF HAIR.

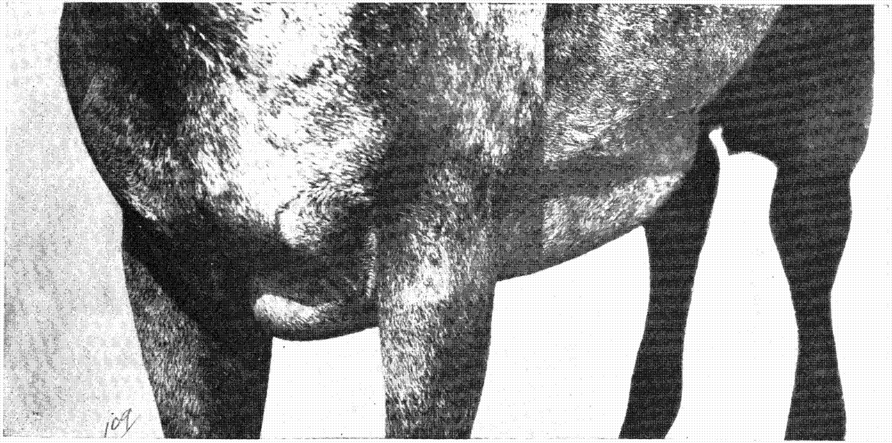


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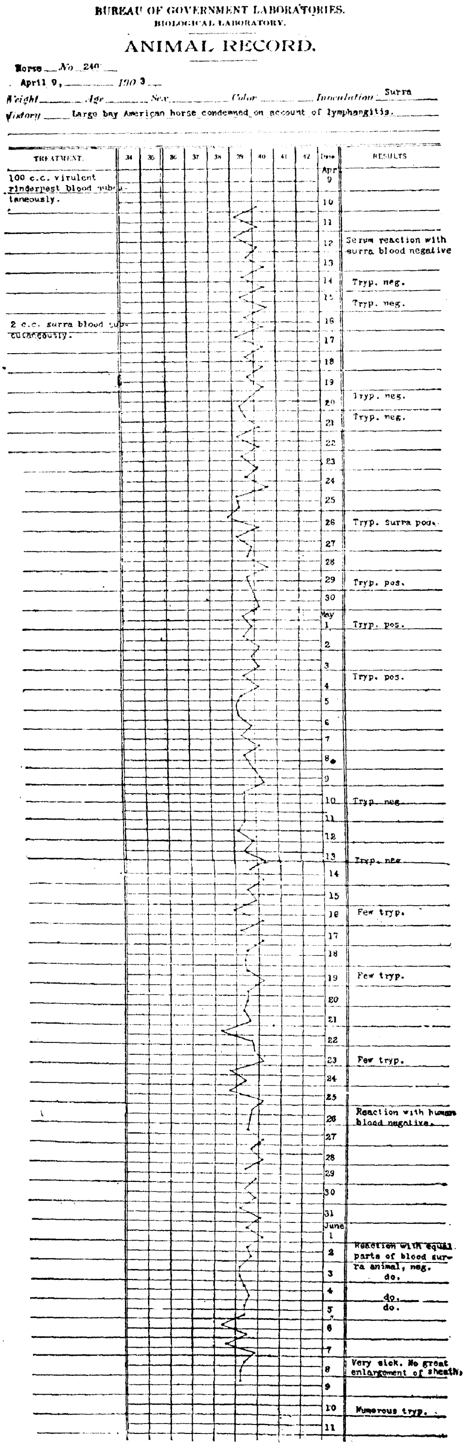
FIG. 123.—SHOWING EDEMA COVERING ABDOMEN AND EXTENDING WELL UP BETWEEN FRONT LEGS; ALSO LARGE PAD ON RIGHT BREAST.



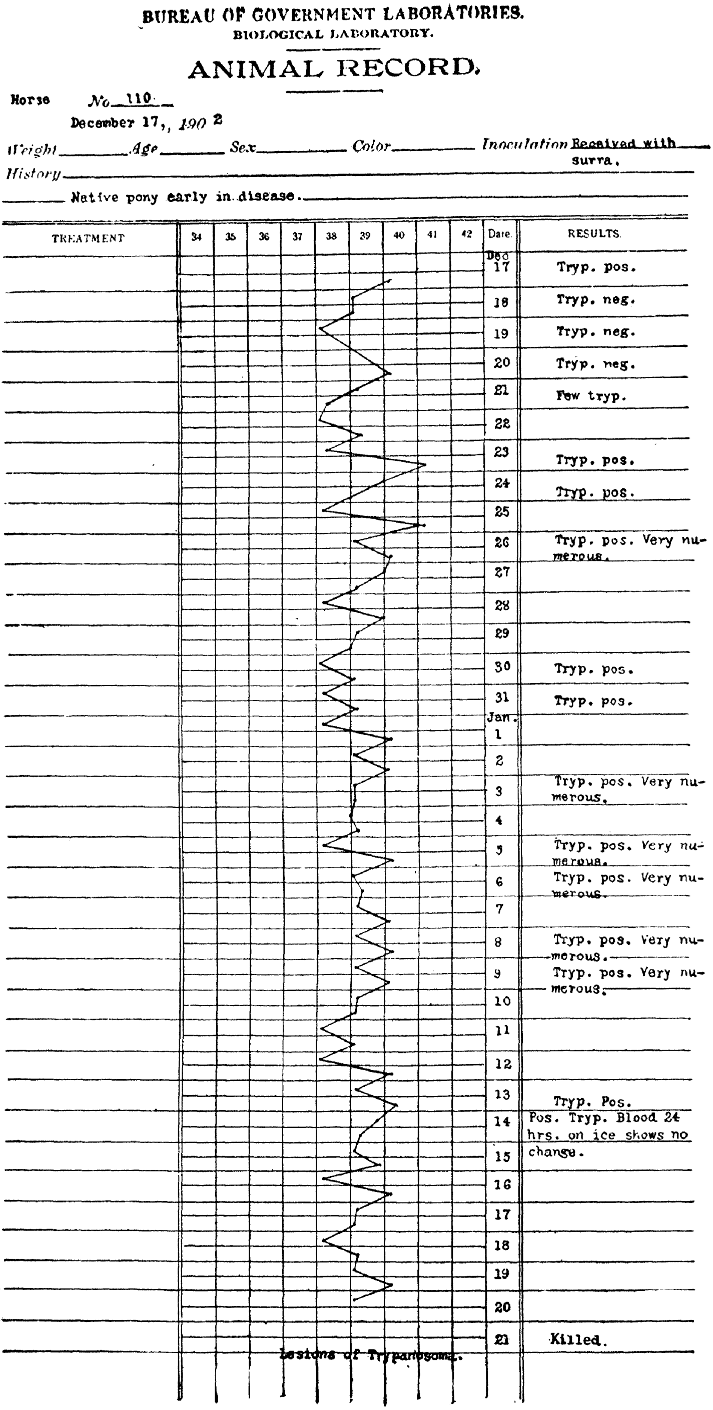
BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Horse No 240
April 9, 1903
Weight ____ Age ____ Sex ____ Color ____ Inoculation Surra
History Large bay American horse condemned on account of lymphangitis.

TREATMENT.	Date	RESULTS
100 c.c. virulent rinderpest blood subcutaneously.	Apr 9	
	10	
	11	
	12	Serum reaction with surra blood negative
	13	
	14	Tryp. neg.
	15	Tryp. neg.
2 c.c. surra blood subcutaneously.	16	
	17	
	18	
	19	
	20	Tryp. neg.
	21	Tryp. neg.
	22	
	23	
	24	
	25	
	26	Tryp. Surra pos.
	27	
	28	
	29	Tryp. pos.
	30	
	May 1	Tryp. pos.
	2	
	3	Tryp. pos.
	4	
	5	
	6	
	7	
	8	
	9	
	10	Tryp. neg.
	11	
	12	
	13	Tryp. neg.
	14	
	15	
	16	Few tryp.
	17	
	18	
	19	Few tryp.
	20	
	21	
	22	
	23	Few tryp.
	24	
	25	
	26	Reaction with human blood negative.
	27	
	28	
	29	
	30	
	31	
	June 1	
	2	Reaction with equal parts of blood surra animal, neg.
	3	do.
	4	do.
	5	do.
	6	
	7	
	8	Very sick. No great enlargement of sheath.
	9	
	10	Numerous tryp.
	11	

FIG. 118.—Temperature record of surra in an American horse.



BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Horse No. 110
December 17, 1902

Weight ______ Age ______ Sex ______ Color ______ Inoculation Received with surra.

History

Native pony early in disease.

TREATMENT	Date.	RESULTS.
	Dec. 17	Tryp. pos.
	18	Tryp. neg.
	19	Tryp. neg.
	20	Tryp. neg.
	21	Few tryp.
	22	
	23	Tryp. pos.
	24	Tryp. pos.
	25	
	26	Tryp. pos. Very numerous.
	27	
	28	
	29	
	30	Tryp. pos.
	31	Tryp. pos.
	Jan. 1	
	2	
	3	Tryp. pos. Very numerous.
	4	
	5	Tryp. pos. Very numerous.
	6	Tryp. pos. Very numerous.
	7	
	8	Tryp. pos. Very numerous.
	9	Tryp. pos. Very numerous.
	10	
	11	
	12	
	13	Tryp. Pos.
	14	Pos. Tryp. Blood 24 hrs. on ice shows no change.
	15	
	16	
	17	
	18	
	19	
	20	
	21	Killed.

Lesions of Trypanosoma.

FIG. 119.—Temperature record of surra in a native pony.

be erythematous, macular, or urticarial. We have occasionally noted in well-advanced cases bunches of macules, somewhat concentric in form, which became pustular and finally covered with a scaly exudate caused by the drying of the purulent-looking discharge from the pustules.

Catarrhal symptoms, of the eyes particularly and less noticeable also of the nose, manifest themselves rather early in the disease, although they may come on late and in some cases are almost wholly absent throughout its course. At first the discharge is small in amount and watery, but as the disease progresses becomes more abundant and mucus-like, and finally takes on a yellowish tinge, becomes tenaceous, and often coagulates in the inner canthi of the eyes.

Subcutaneous œdema, more or less marked, is a constant symptom, but varies greatly in the time of its appearance. In some cases it is seen early in the disease, becoming a very prominent symptom, while in others it comes on late and is very insignificant. Its intensity does not appear to bear any relation to the duration of the disease. In nearly every instance it is first noticed around the genitalia (figs. 106, 120), which remain in the majority of cases the most severely involved part. From the sheath it spreads forward along the belly on both sides of the linea alba in two well-defined bands (figs. 107, 121), which may extend between the forelegs, where they then unite and pass on to the chest as a large pod, as illustrated in figures 109, 123. When the swelling becomes marked the two bands under the belly may unite. The œdema extends also down the hind legs, being most marked below the hock. The forelegs may also be involved, but to a less extent. Other places which occasionally show this swelling are the nose and the loose tissues around the eyes, the base of the jaw, the throat, and the base of the ears, but it is rare to see these parts involved to any considerable extent.

One of the earliest symptoms following a rise in temperature is the pallor of the mucous membranes, which first become pearly white and then take on a decided yellowish tinge. In a well-marked case this symptom alone is almost sufficient to make a diagnosis. The mucosa of the mouth, tongue, eyes, and nose assume a ghastly whiteness, which is out of all proportion to the pleural anemia. Before death these membranes become somewhat yellowish, a change which gives a jaundice-like appearance, but is of the same character as that seen in some of the other tissues of the body, and described as a gelatinous infiltration.

Symptoms of the organs of special sense are important. In many cases vision is impaired and total blindness may be brought about, usually by the clouding of the aqueous humor, which in such cases as a rule contains parasites. The sense of hearing is also involved, but generally to a much less extent.

Enlargement of the submaxillary and, to a less degree, of the other subcutaneous glands is a frequent symptom. In some instances the submaxillary glands may be greatly swollen and very sensitive to the touch; and again we have seen animals without any apparent enlargement or tenderness of these organs during the entire course of the disease. When trypanosomiasis is once well established respiration is usually quickened and in many instances more or less labored, as is evidenced by the bellow-like movement of the abdominal walls. These symptoms are intensified whenever broncho-pneumonia complicates the disease.

There are often no gastro-intestinal symptoms of importance, but in most cases a very severe diarrhea develops during the later stages, generally ten or twelve days before death.

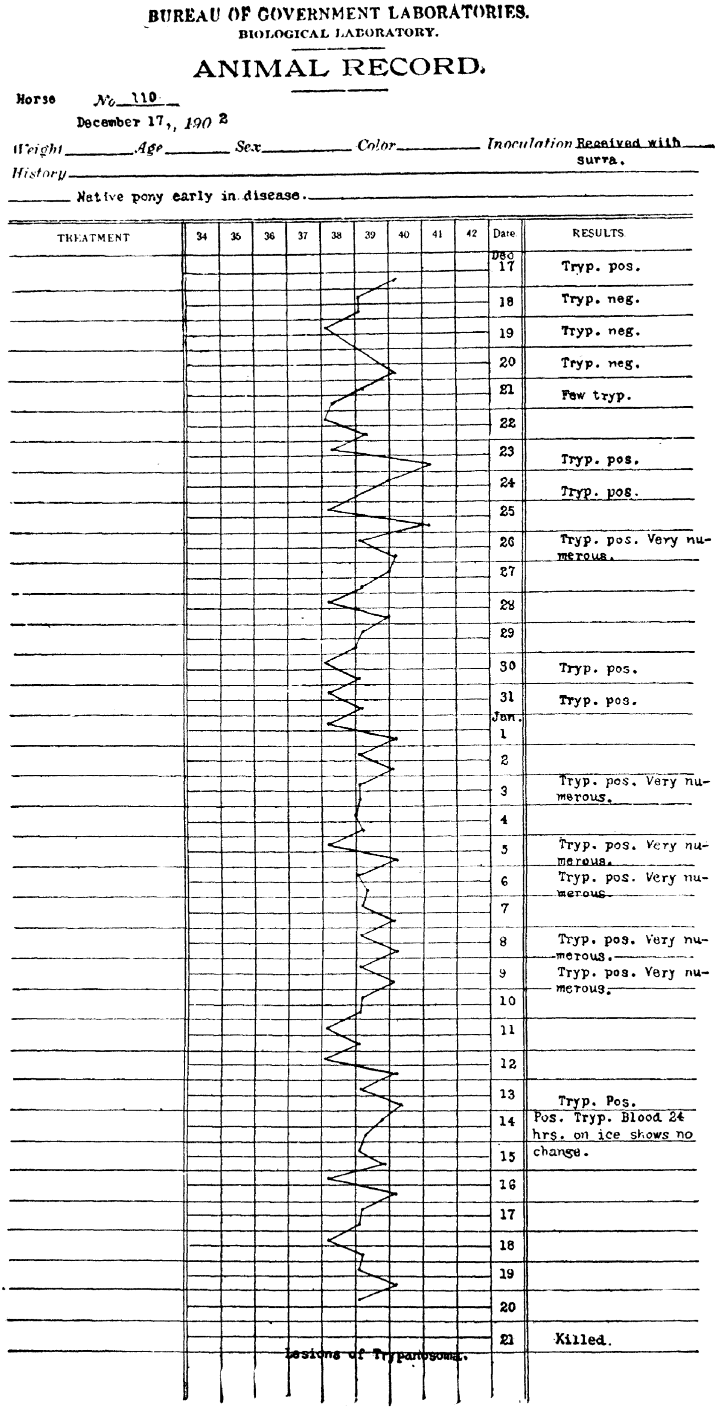
The nervous symptoms vary considerably in the horse. In the larger number of cases the described incoordination of movement and the partial paralysis of the hind quarters are present to a certain extent, while cases are met with in which these symptoms do not at any time manifest themselves.

The morbid anatomy has already been considered in the chapter devoted to a general discussion of this subject.

TRYPANOSOMIASIS OF MULES.

Very little in regard to trypanosomiasis of mules is found in literature, excepting the bare statement that these animals are susceptible and have a long period of illness. Voges says that the duration of the disease may be a year or more, but that often the parasites are not found by microscopic examination for days or weeks at a time, and that he would not be surprised at some future time to find an immune animal.

The disease in these animals in the Philippine Islands is of longer duration, just as is true in other infected zones. This fact might be taken advantage of in bettering conditions in countries where surra is prevalent and where means of eradication and prevention are not applicable, because these animals may be used for a long time



BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Horse *No.* 110
December 17,, *190* 2

Weight ________ *Age* ________ *Sex* ________ *Color* ________ *Inoculation* Received with surra.

History ________ Native pony early in disease.

TREATMENT	34	35	36	37	38	39	40	41	42	Date	RESULTS
										Dec. 17	Tryp. pos.
										18	Tryp. neg.
										19	Tryp. neg.
										20	Tryp. neg.
										21	Few tryp.
										22	
										23	Tryp. pos.
										24	Tryp. pos.
										25	
										26	Tryp. pos. Very numerous.
										27	
										28	
										29	
										30	Tryp. pos.
										31	Tryp. pos.
										Jan. 1	
										2	
										3	Tryp. pos. Very numerous.
										4	
										5	Tryp. pos. Very numerous.
										6	Tryp. pos. Very numerous.
										7	
										8	Tryp. pos. Very numerous.
										9	Tryp. pos. Very numerous.
										10	
										11	
										12	
										13	Tryp. Pos.
										14	Pos. Tryp. Blood 24 hrs. on ice shows no change.
										15	
										16	
										17	
										18	
										19	
										20	
										21	Killed.

Lesions of Trypanosoma.

FIG. 119.—Temperature record of surra in a native pony.

be erythematous, macular, or urticarial. We have occasionally noted in well-advanced cases bunches of macules, somewhat concentric in form, which became pustular and finally covered with a scaly exudate caused by the drying of the purulent-looking discharge from the pustules.

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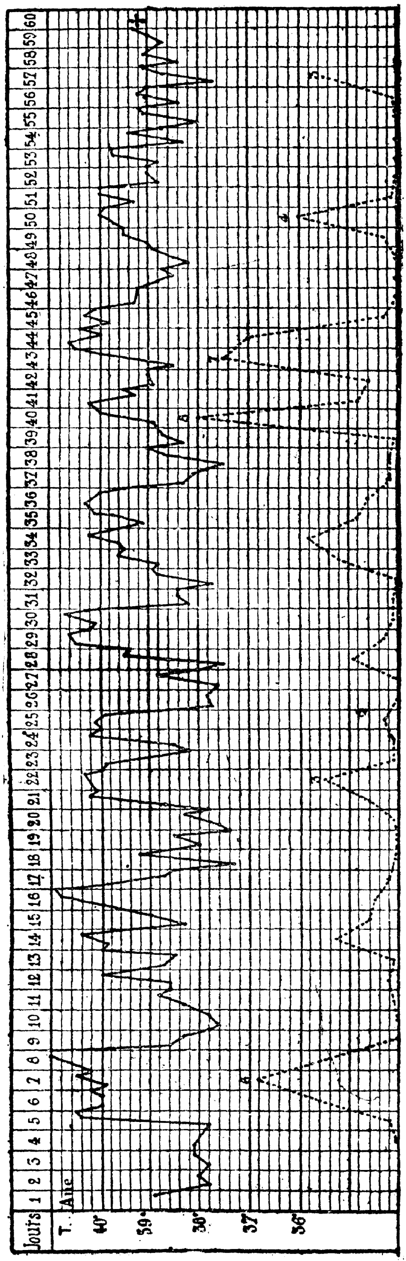


FIG. 124.—Nagana in the ass. (——) Temperature. (……) Trypanosoma. (After Laveran and Mesnil, 1902, fig. 3.)

without becoming useless through exhaustion incident to the disease. Mules are largely used as draft animals by the military and civil governments of the Philippine Islands and are being introduced to an increasing extent in private enterprises.

By inoculation they are just as susceptible to trypanosomatic infection as horses, but they appear to be less frequently attacked by natural infection; this is no doubt partly owing to the fact that flies disturb them less.

The symtoms in general are similar to those described for the horse; but there are certain slight differences. The temperature is less remittent and more rarely intermittent, and we have not seen a single case in which the fever was of a relapsing type. Edema, weakness, and anemia are slower in their appearance, but when once well established show no suggestive differences.

The parasites, as determined by microscopic examination, as a rule are not so numerous in the peripheral circulation as they are in that of the horse, and the periods during which they are not found at all are more frequent and of longer duration. However, just as in horses, the blood is constantly infectious by inoculation throughout the course of the disease. The incubation period is the same as in the horse, the duration from four to twelve weeks or even longer, and the mortality 100 per cent.

As a general rule skin lesions are more constant and decided than in the case of the horse, although of the same general character. The localization of symptoms in the skin and genitals is more noticeable in animals showing some resistance to the infection than in others, so that in some of the lower animals—such as the rabbit—we have a very satisfactory clinical picture of dourine.

The morbid anatomy in mules is very similar to that of the horse, which has already been discussed.

TRYPANOSOMIASIS OF ASSES.

According to Laveran and Mesnil, nagana shows the same general character of infection in these animals as it does in the horse. The course of the temperature is more irregular, and the relation of the number of parasites in the peripheral circulation to the temperature is more constant. As a rule, they are less numerous in the blood and may be entirely absent for longer periods of time. The local symptoms, particularly edema, are said to be scarcely noticeable in these animals. The average duration of the disease is given by these authors as fifteen days.

Voges states that asses are invariably susceptible to mal de caderas, and that the symptoms of the disease in them do not differ from those described for mules. Koch found the asses of Massai immune to the infection. He does not appear, however, to have demonstrated the immunity of these animals by inoculation; and as all other writers, referring to the susceptibility of the various species of asses, have always found them to be capable of contracting the disease, we can not but feel sceptical about Koch's conclusions. Lingard mentions particularly the chronic course of surra in the donkey. There are no asses in the Philippines, so that we have been unable to perform any work on these animals.

TRYPANOSOMIASIS OF OTHER EQUIDES.

All other equides, including hybrids, have been shown to be susceptible by various writers, although very little on the course of the disease in these animals is given in detail. As they are not of any economic importance in these islands, no consideration will be given them here.

TRYPANOSOMIASIS OF CATTLE.

The great variations in results obtained in the study of this family of animals and their undoubted great importance in perpetuating epidemics make it one of the most important to be considered. In nearly all countries where the infection is prevalent cattle have been found to be susceptible.

With reference to the course of trypanosomiasis in cattle and the mortality of these animals, there is wide difference of opinion in the same country, as well as in different ones. So far as we know, Voges, in South America, is the only writer who states positively that some cattle are not susceptible. He is certain the cattle of that country do not contract the disease after being inoculated.

Certain writers in Africa maintain that cattle are very susceptible to nagana, with a high mortality. Others, as Schilling, have shown the infection not to be invariably virulent for these animals, the course of the disease to be long, and the mortality low, some cases of complete recovery being reported. Laveran and Mesnil, working with *Trypanosoma* of nagana in France, obtained a long course of the disease in

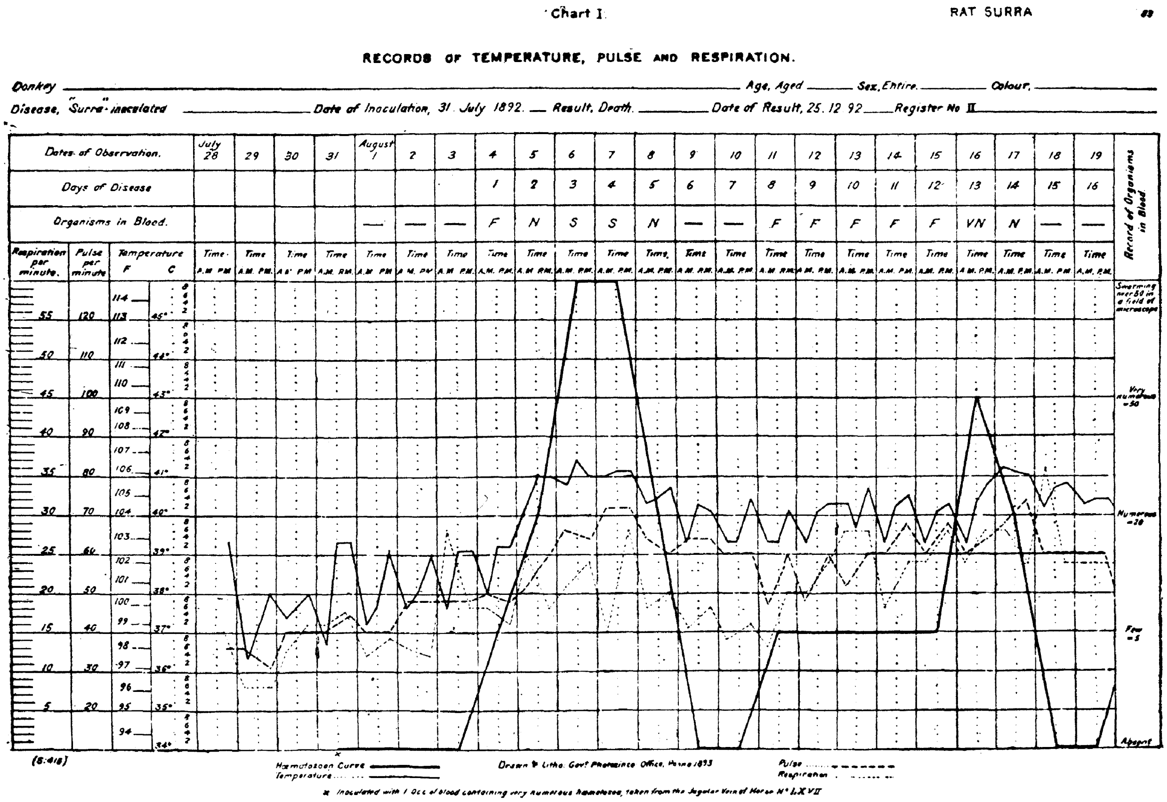


FIG. 125.—Temperature record of surra in a donkey. (After Lingard.)

RAT SURRA

Chart II.

RECORDS of TEMPERATURE, PULSE AND RESPIRATION.

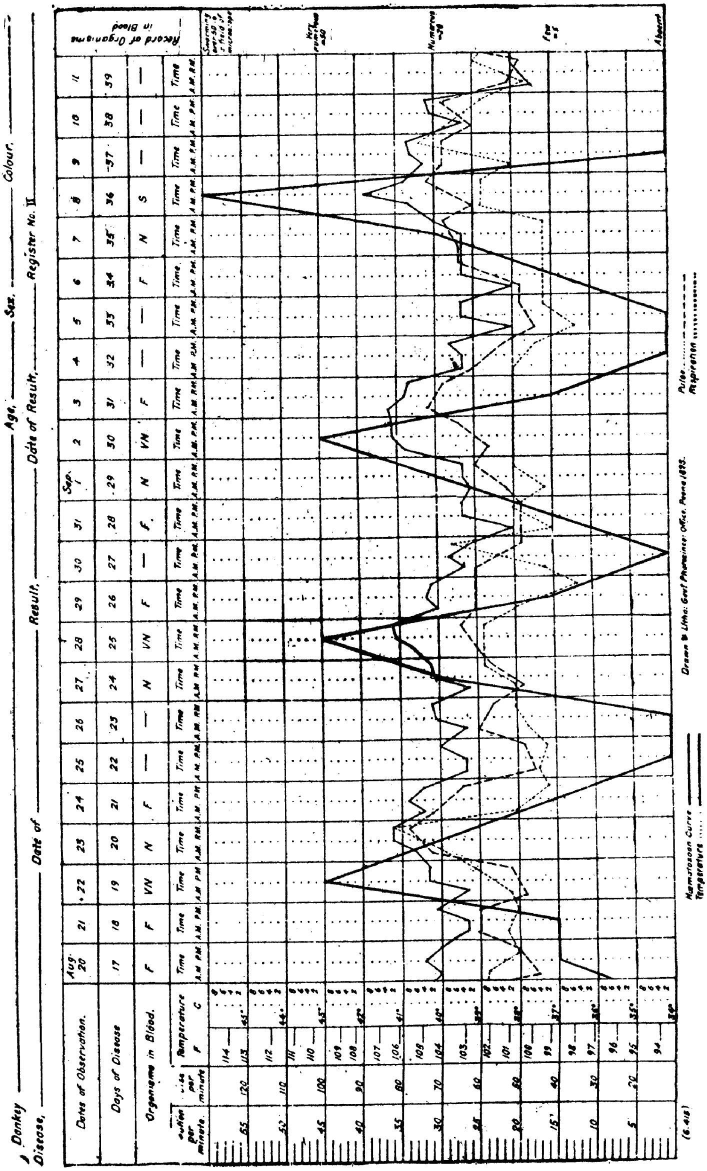


FIG. 125—Continued.

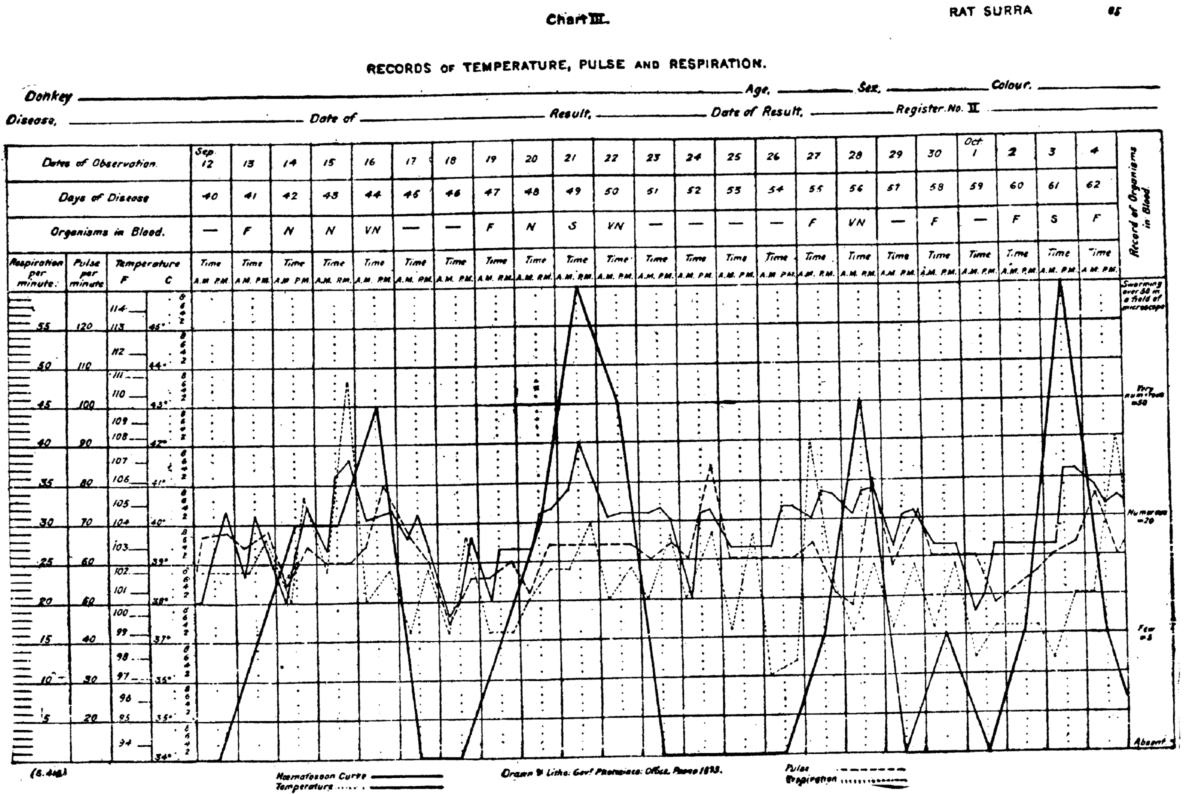


Chart III.

RAT SURRA 85

RECORDS OF TEMPERATURE, PULSE AND RESPIRATION.

Donkey ______ Age, ______ Sex, ______ Colour, ______

Disease, ______ Date of ______ Result, ______ Date of Result, ______ Register No. II

Dates of Observation.	Sep. 12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Oct. 1	2	3	4
Days of Disease	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
Organisms in Blood.	—	F	N	N	VN	—	—	F	N	S	VN	—	—	—	—	F	VN	—	F	—	F	S	F

FIG. 125—Continued.

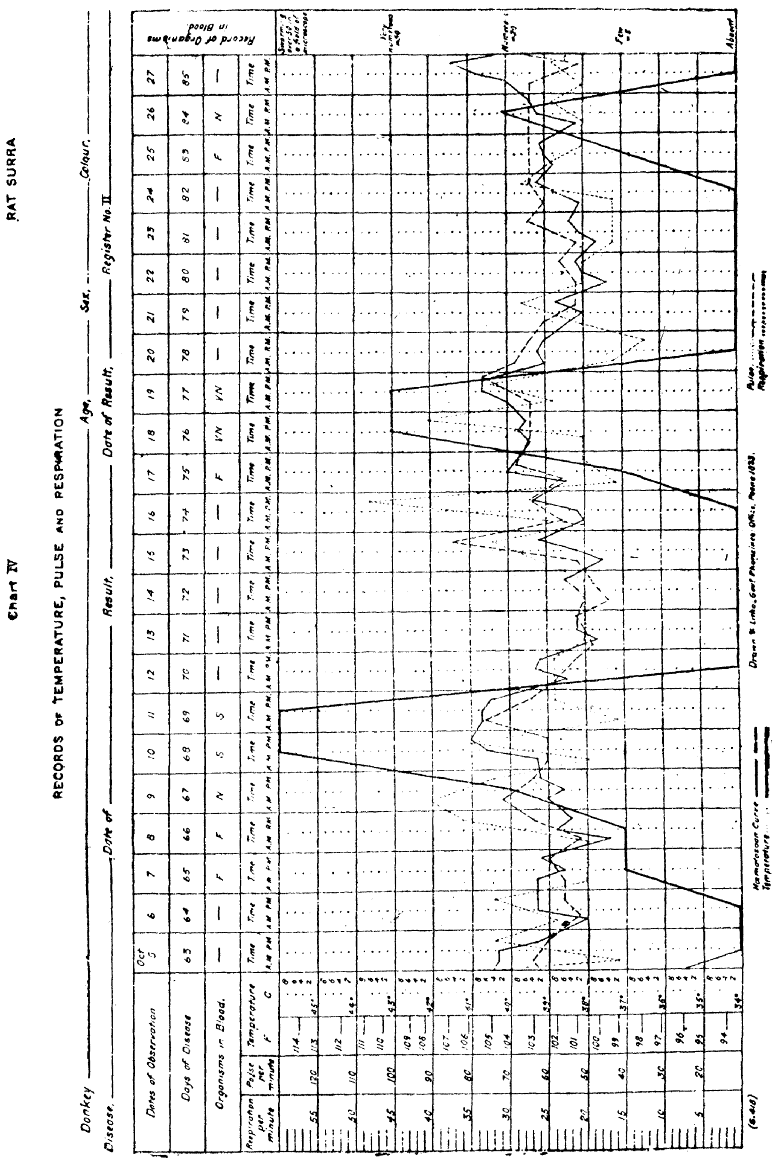


FIG. 125—Continued.

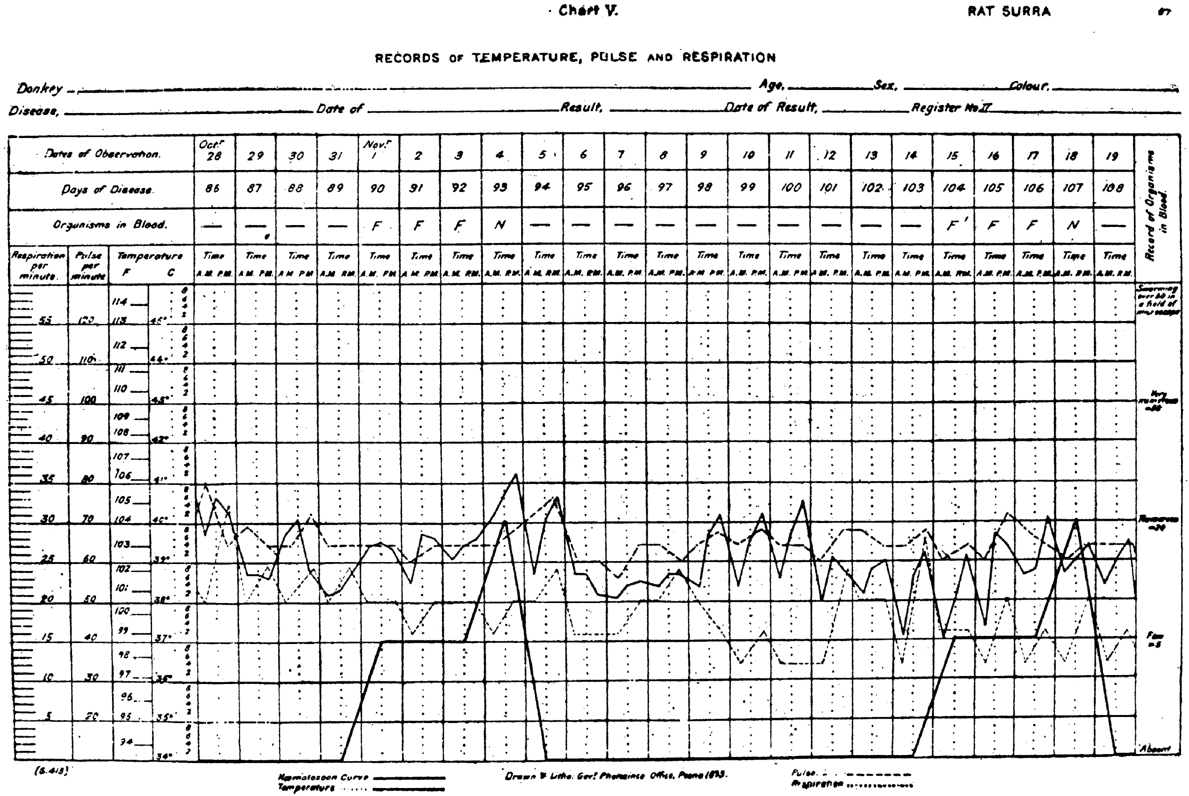


FIG. 125—Continued.

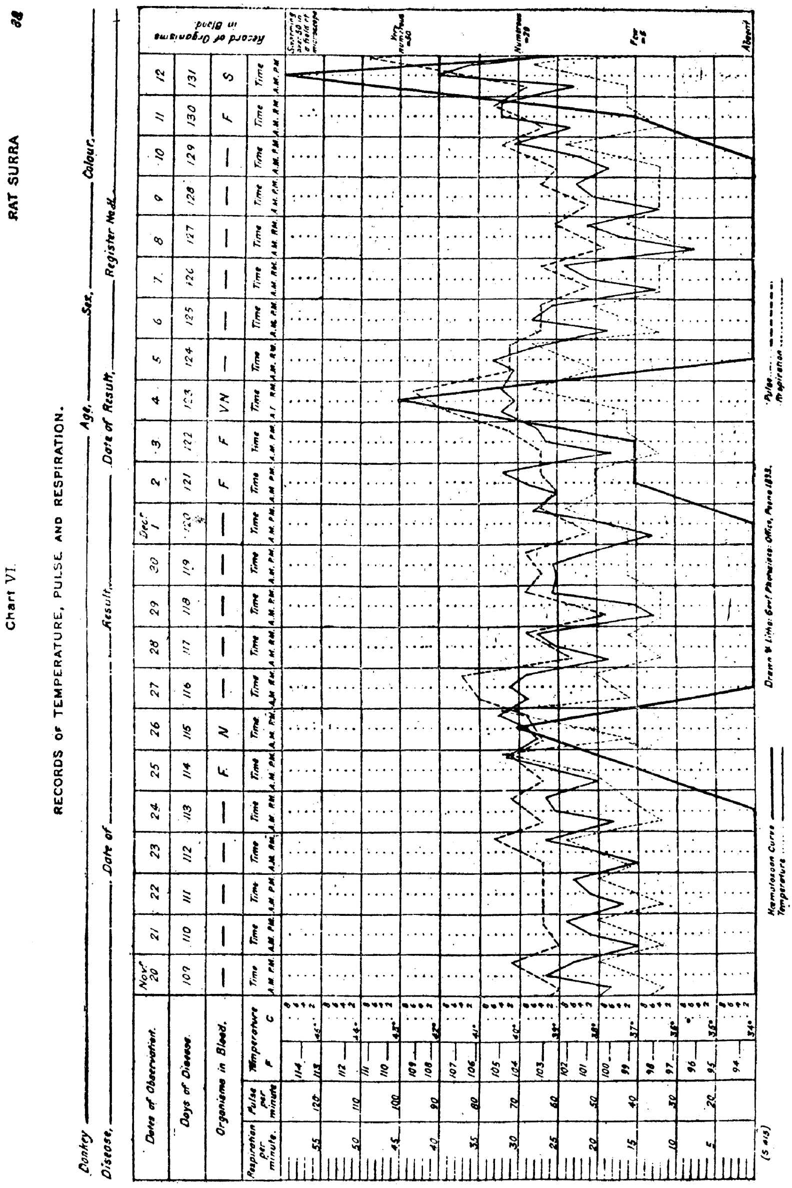


FIG. 125—Continued.

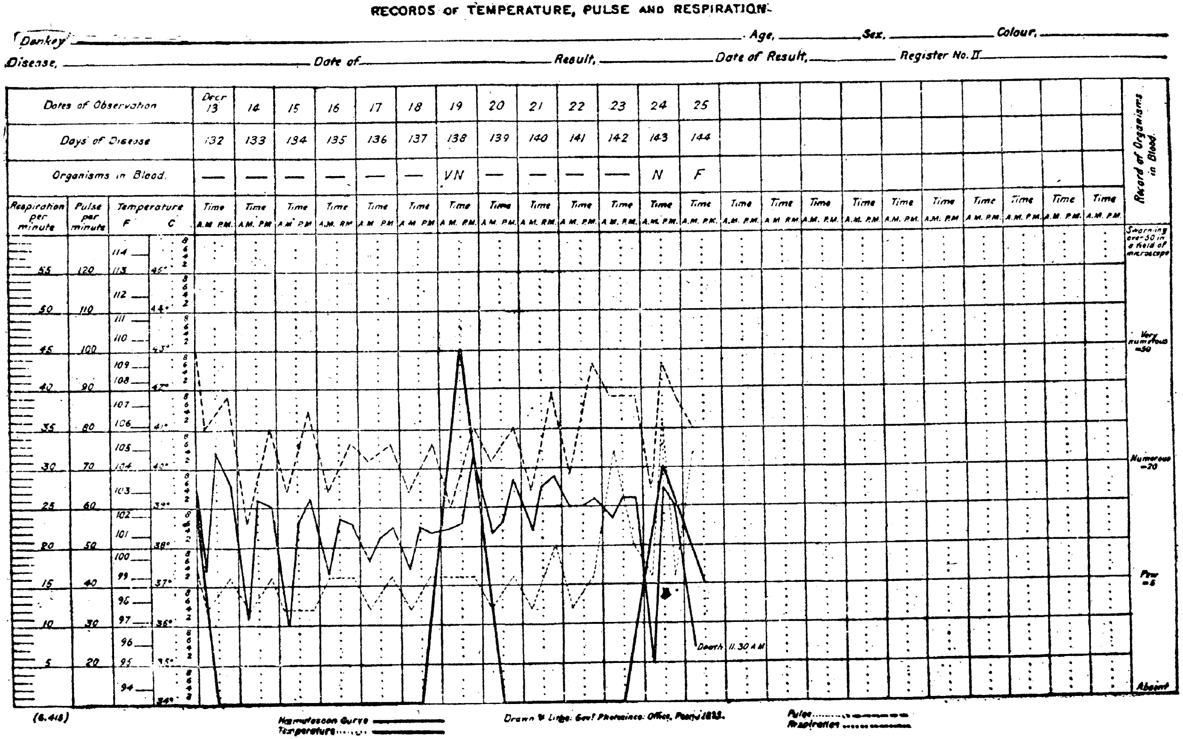


FIG. 125—Continued.

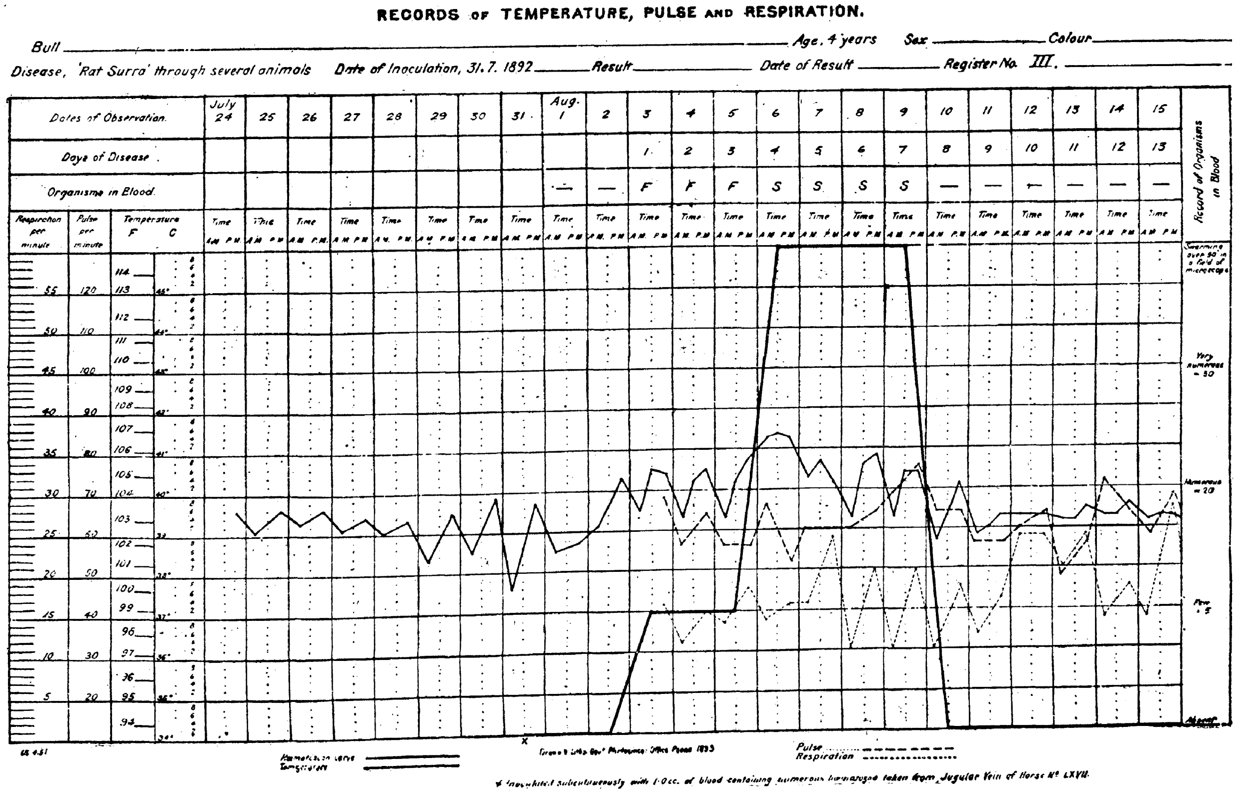


FIG. 126.—Temperature record of surra in a bull. (After Lingard.)

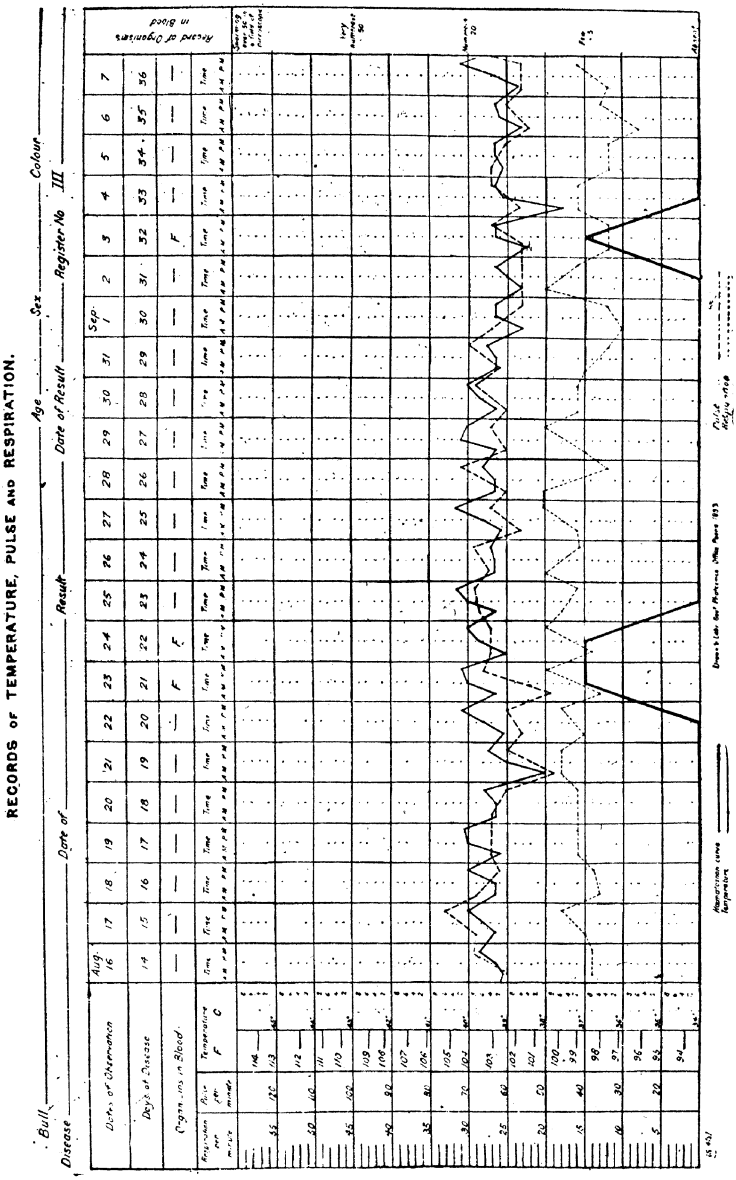


FIG. 126—Continued.

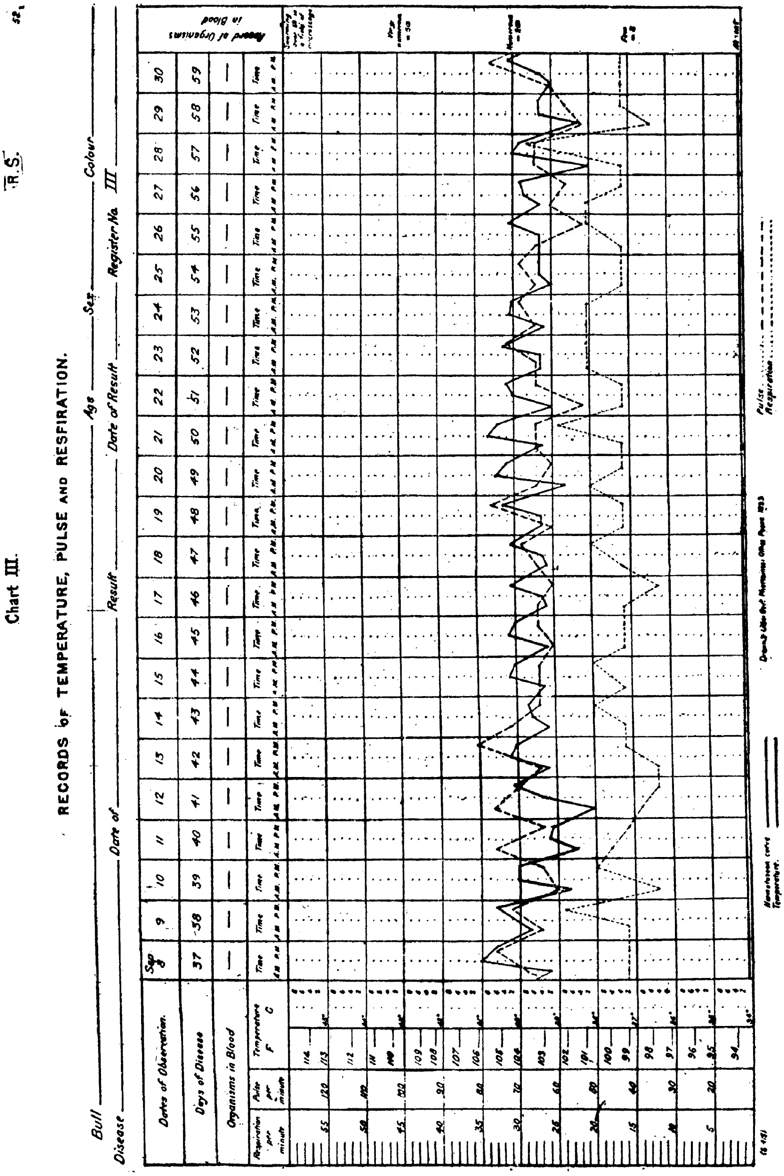


FIG. 126.—Continued.

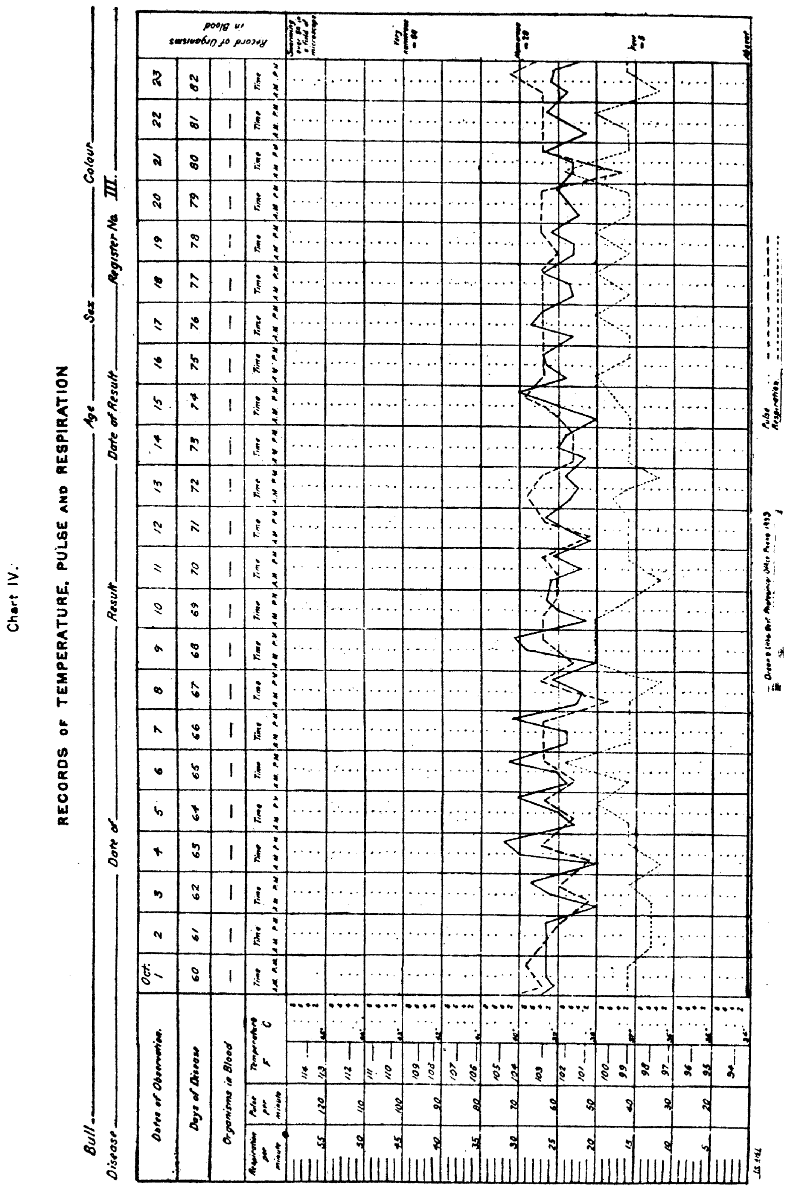


FIG. 126.—Continued.

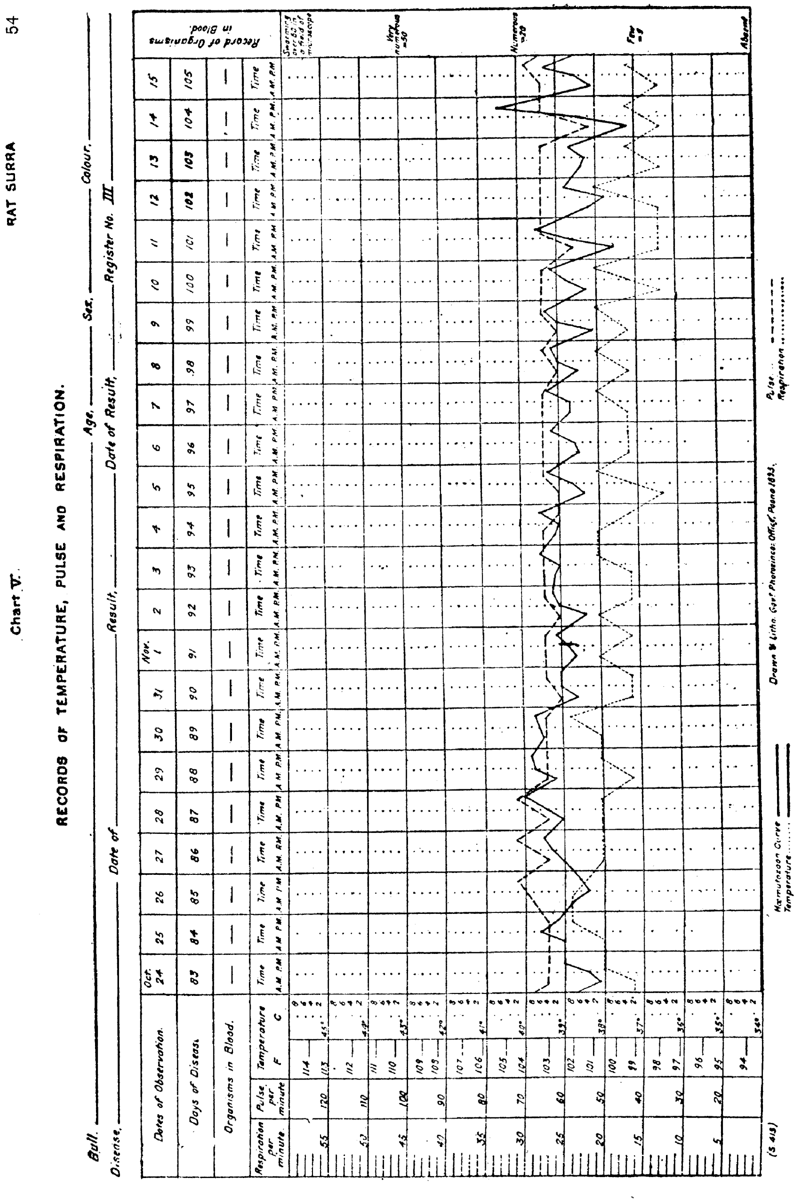


FIG. 126.—Continued.

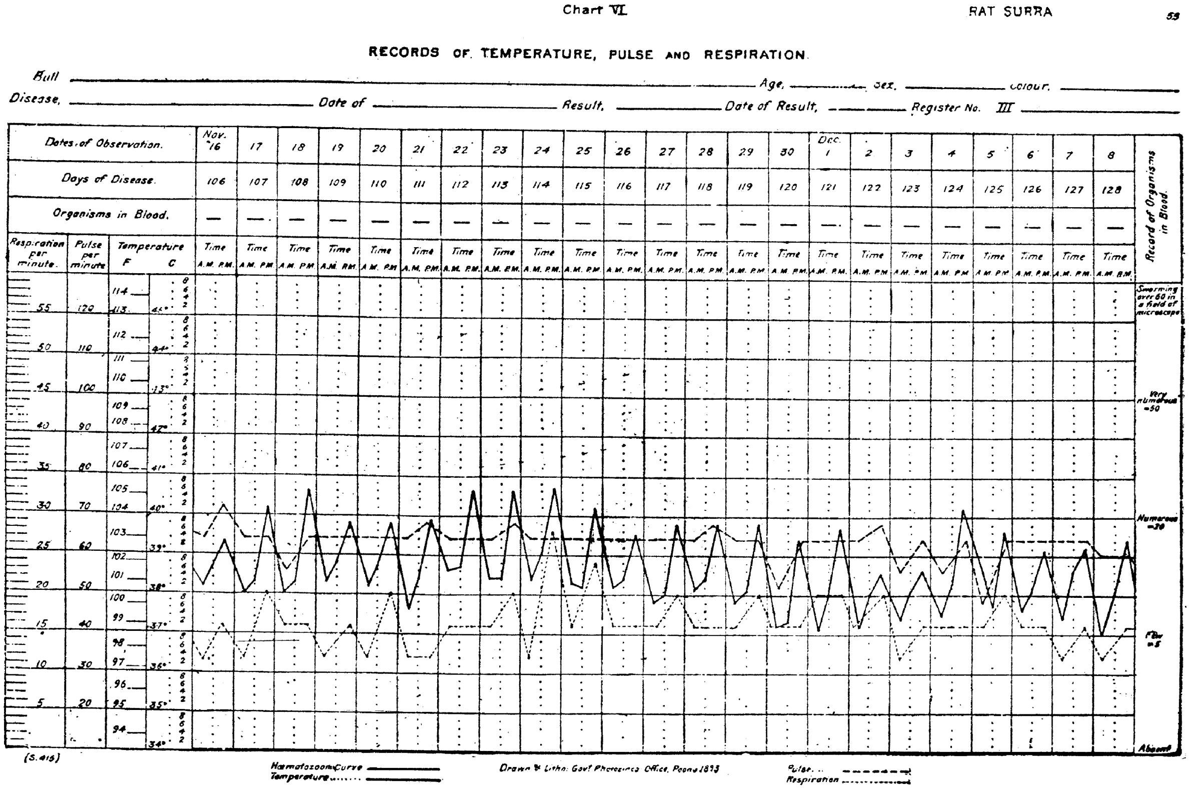


FIG. 126—Continued.

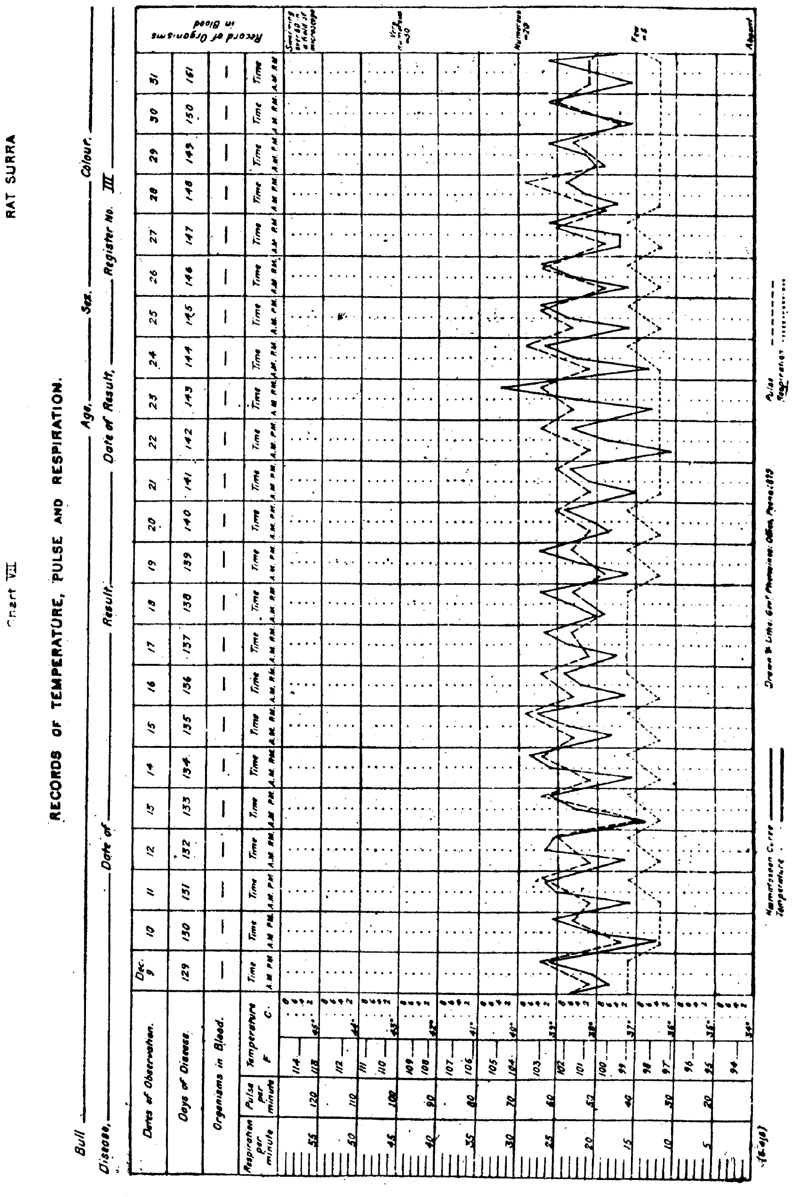


FIG. 126—Continued.

BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

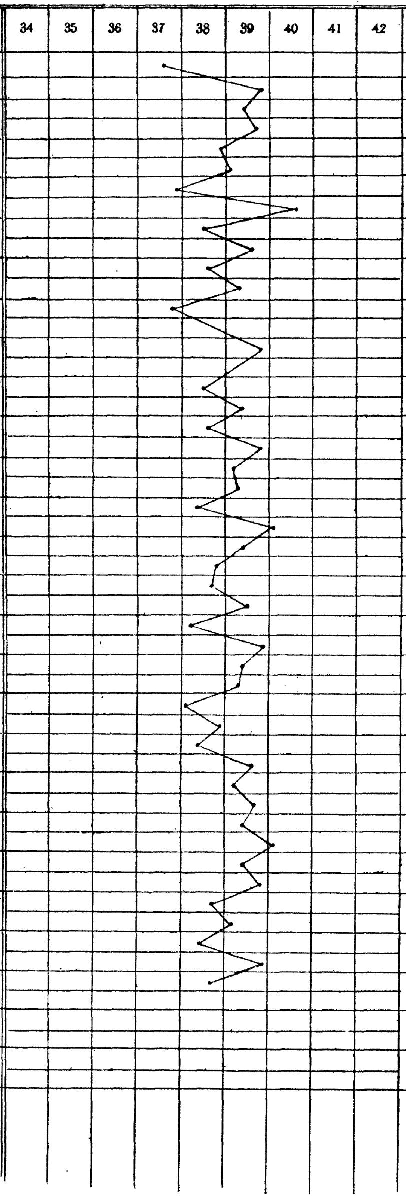
ANIMAL RECORD.

Cow *No.* 280

June 1, *190*3

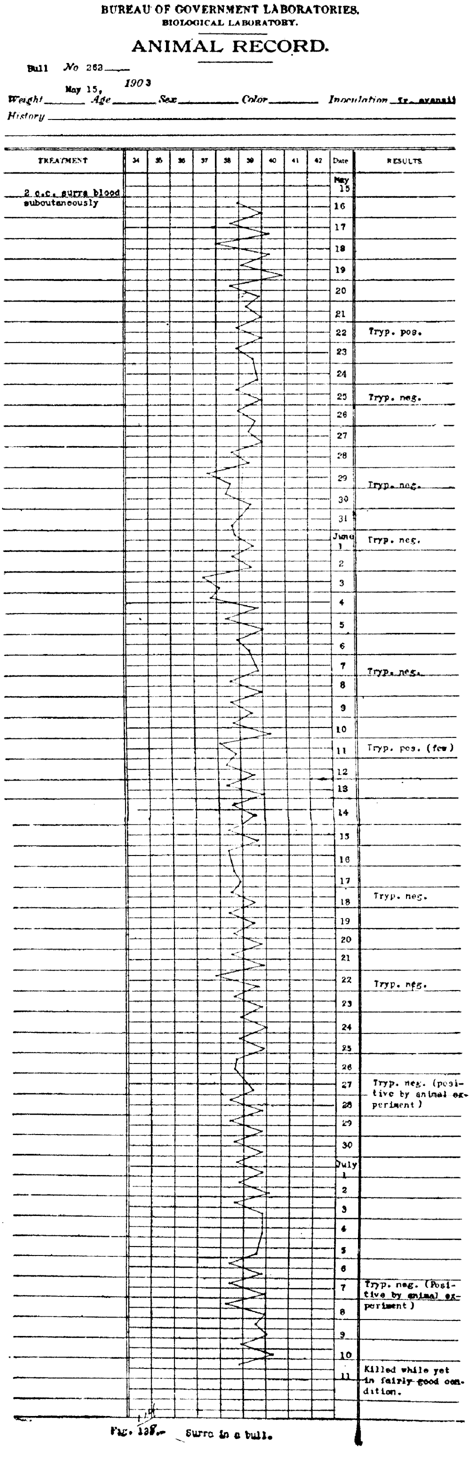
Weight 500 lbs. *Age* 8 yrs. *Sex* Male *Color* Red *Inoculation* Surra.

History Rinderpest serum animal under observation for several months.



TREATMENT.	Date.	RESULTS.
	June	
1500 c.c. bleed of	1	
cow suffering from surra.	2	
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	
	11	
	12	
	13	
	14	
	15	Tryp. neg.
	16	Tryp. neg.
	17	Tryp. neg. Monkey ~~given 1 c.c. blood~~
	18	Tryp. neg.
	19	Tryp. neg.
	20	Tryp. neg.
	21	Tryp. neg.
	22	Tryp. neg.
	23	
	24	

FIG. 127.—Surra in cow with very rapid course.



BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Bull No 263
May 15, 1903
Weight ____ Age ____ Sex ____ Color ____ Inoculation Tr. evansi
History ____

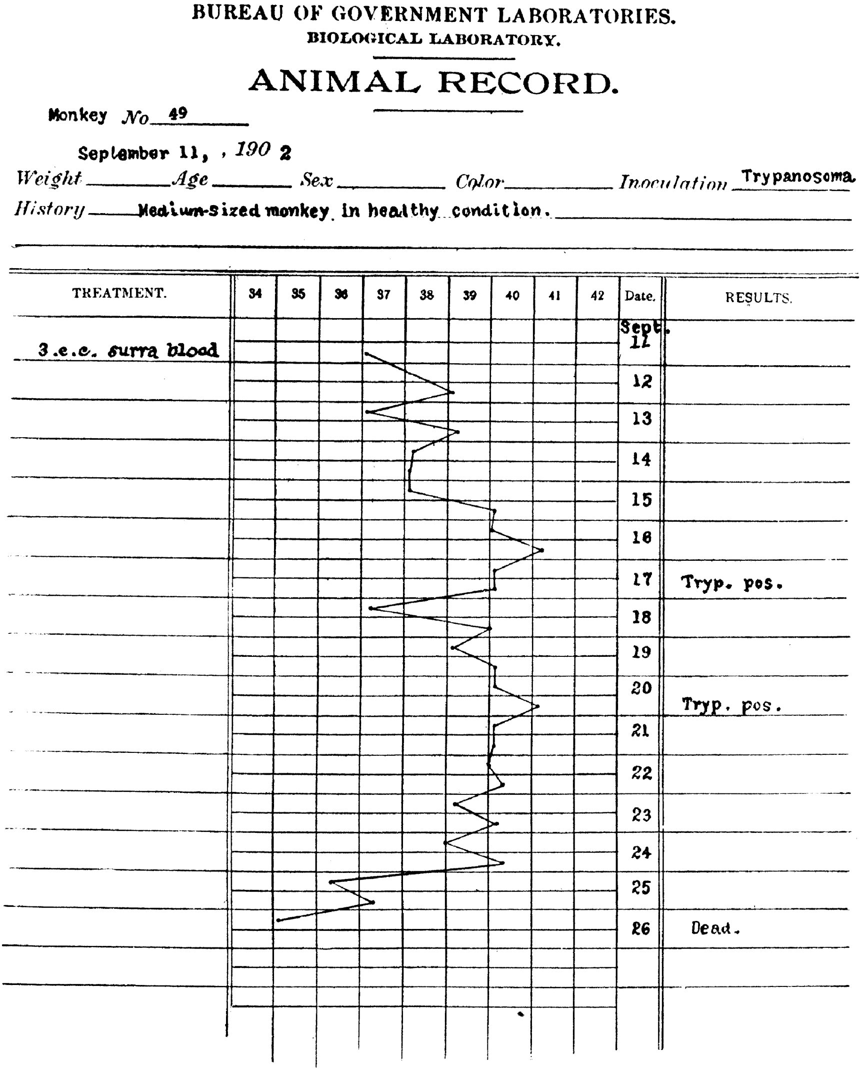
TREATMENT	34	35	36	37	38	39	40	41	42	Date	RESULTS
2 c.c. surra blood subcutaneously										May 15	
										16	
										17	
										18	
										19	
										20	
										21	
										22	Tryp. pos.
										23	
										24	
										25	Tryp. neg.
										26	
										27	
										28	
										29	Tryp. neg.
										30	
										31	
										June 1	Tryp. neg.
										2	
										3	
										4	
										5	
										6	
										7	Tryp. neg.
										8	
										9	
										10	
										11	Tryp. pos. (few)
										12	
										13	
										14	
										15	
										16	
										17	
										18	Tryp. neg.
										19	
										20	
										21	
										22	Tryp. neg.
										23	
										24	
										25	
										26	
										27	Tryp. neg. (positive by animal experiment)
										28	
										29	
										30	
										July 1	
										2	
										3	
										4	
										5	
										6	
										7	Tryp. neg. (Positive by animal experiment)
										8	
										9	
										10	
										11	Killed while yet in fairly good condition.

Fig. 128.- Surra in a bull.

FIG. 128.—Surra in a bull.

infected animals, and the mortality was certainly much lower than the reports usually received from Africa would indicate for that country. Writers in India practically all agree that cattle are susceptible to the disease, but mention its long course, lower mortality, and some cases of complete recovery.

Bruce states that the duration of nagana varies from a week to six months or more. The symptoms are much less marked than in horses or dogs. Emaciation is rapid; the hair becomes rough and falls out; fluid runs froms the nose and eyes, and there is a tendency to diarrhea. The dewlap becomes edematous, but the edema is not so prominent on the abdomen and posterior extremities as in the infection of the horse. Fever is constant, but not so high as in the case of horses, occasionally reaching 41° C. Parasites are rare in the blood.



BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Monkey *No* 49

September 11, *190* 2

Weight ________ *Age* ________ *Sex* ________ *Color* ________ *Inoculation* Trypanosoma

History Medium-sized monkey in healthy condition.

TREATMENT.	34	35	36	37	38	39	40	41	42	Date.	RESULTS.
3 c.c. surra blood										Sept. 11	
										12	
										13	
										14	
										15	
										16	
										17	Tryp. pos.
										18	
										19	
										20	Tryp. pos.
										21	
										22	
										23	
										24	
										25	
										26	Dead.

FIG. 129.—Temperature record of surra in a monkey.

Schat, working with the surra of Java, maintains that the disease is very virulent in that country for these animals, stating that the mortality is enormous, the infection sometimes being acute and of short duration, and at others chronic with a longer course. However, as already stated, from Schat's description of the disease we can not but believe that there was some other element present to complicate his cases. He unquestionably worked with trypanosomiasis and *Trypanosoma* were no doubt present, but his description of the symptomatology and the morbid lesions greatly resembles those of rinderpest. It seems more than likely that he was working with a combination of these two diseases.

Theiler observed in the cattle of South Africa an acute pernicious ænemia with only slight fever, which he considered due to a special *Trypanosoma* named by Laveran and Mesnil *Trypanosoma theilerii.*

Lingard speaks particularly of recurrent transient urticarial eruptions in cattle suffering from surra. Great variations were observed in the temperature, the remissions always being observed in the mornings. Emaciation was usually marked. Parasites were few and intermittently present in the peripheral circulation. He gives the usual incubation period in inoculated cases as four to eleven days, and states that the course is chronic, with no mortality in uncomplicated cases.

In the Philippines very little has been written about this disease in cattle, except that they are susceptible. In our work, which has now covered a period of nearly one year, we have examined the blood of hundreds of animals, and but few cases of natural infection have been found. It may be that during the wet season a large number of these animals suffer from trypanosomiasis. By inoculation they are susceptible, and the course of the disease as well as its symptomatology correspond to the descriptions given by the best authors in other countries.

The incubation period is about the same as in the horse, and the other symptoms begin in very much the same manner. The temperature (figs. 113, 127, 114, 128), as a rule, is less intermittent than in the horse, and does not run so high. No relation can be established between the temperature and the number of parasites. *Trypanosoma* in sufficient numbers to be detected by the usual microscopic examination are intermittently present in the blood, but the latter, as in other animals, is constantly infectious by animal experiment. The appetite usually remains good, but there are transient periods of anorexia in almost all cases, and some animals refuse food for days at a time. The bowels remain normal or show a tendency to constipation.

Emaciation is rapid, and as a rule begins earlier than in the horse. Ænemia, as shown by the pallor of the mucous membranes, is probably less marked than in the horse. The catarrhal symptoms of the nose and eyes are slight in most animals, but in those cases which prove fatal may become a prominent symptom. Edema is decidedly less marked than in the horse, and in some animals is scarcely perceptible, while in others it appears particularly in the dewlap and less so on the abdomen and hind legs. The hair becomes rough and in places falls out. Urticarial eruptions are quite frequent.

On the whole, the picture is similar to that seen in other animals, and in well-advanced cases a diagnosis should be easy. Owing to the scarcity of parasites in the circulating blood and their apparent intermissions, the laboratory diagnosis of these animals should include animal experiment.

The course of the disease is usually chronic, and in animals observed here the mortality is low. In some cases the disease may be very acute; one of our inoculated animals, for example, lived only twenty-four days (fig. 127). We have not been able to examine a sufficiently large number of cases, and for that reason do not desire to give definite figures as to the mortality.

Several varieties of cattle are found in the Philippine Islands in addition to the native ones, these including Australian, Chinese, American, Straits Settlement, and Javanese.

TRYPANOSOMIASIS OF CARABAO.

The Indian buffalo, of which the so-called carabao of the Philippine Islands is a species, has been proved susceptible to surra by Lingard.

The course of the disease in his animals very closely resembled that of the cow. The incubation period was about five days in inoculated animals, and the duration in two of his animals was forty-six and one hundred and twenty days, respectively, followed in each case by death. According to his description there were very distinct exacerbations and remissions of temperature in both cases. The appetite remained good, but emaciation was marked and progressive. Nothing of especial interest was noted at post-mortem examination.

Curry mentions trypanosomiasis of carabaos in the Philippine Islands, but does not give any data of importance.

TRYPANOSOMIASIS OF MONKEYS.

Monkeys, where available, are among the most valuable animals for the study of trypanosomiasis. They are seldom naturally infected, but are very susceptible to inoculation, and run a regular course.

Kanthuck, Durham, and Blandford inoculated a monkey with *Tr. brucei.* During the two weeks of its illness parasites were constantly present. The post-mortem examination showed advanced pulmonary tuberculosis.

Nocard subcutaneously inoculated an old monkey with several drops of blood from a nagana mouse. He gives the incubation period as four days and the duration of the disease as fifteen days. Parasites were very numerous throughout its course and at the time of death exceeded the red-blood cells in number. The principal symptoms were high temperature, œdema of the eyelids and pockets, and dejection of spirit.

Sivori and Lecler give the incubation period in "surra americain" as three days, followed by death about the sixth day. The temperature is high at first, and just before death drops to 36° C. Anemia is rapid and progressive. The appetite remains good. Toward the end there is some drowsiness, followed by death in coma. The post-mortem examination shows an enlarged spleen with dark-red pulp, œdema of the lungs, and a small quantity of citrin liquid in the serous sacs.

Voges says that a monkey (*Nictipitechus felinus*) inoculated with *Tr. equinum* succumbed to the disease. Several observers in India have shown monkeys to be susceptible by inoculation to the surra of that country; they have also been proved capable of contracting dourine.

Monkeys have been extensively used in our work, and the following statements are based upon the clinical and post-mortem study of a large number of these animals. In the course of this investigation the blood of hundreds of monkeys from all parts of the islands, from infected areas and from those not infected, has been examined, and only once has a naturally infected animal been found, although they are very susceptible to the disease, which, when given by inoculation, invariably proves fatal.

The incubation period in these animals varies with the manner of inoculation, being on the average one to three days by subcutaneous or scratch inoculation, whether by syringe or insect, and somewhat shorter by intra-abdominal inoculation. The duration is from five to thirty-five days and the mortality 100 per cent.

Monkeys are the only animals that show undoubted evidence of having pain caused by the infection. The manner in which for hours at a time they hold their heads between their hands leaves little doubt but that they suffer from headache.

The character of the fever varies considerably (figs. 115–118, 129–132). It is generally intermittent or markedly remittent, and always higher in the afternoons. In some cases it may be nearly continuous, especially in the later stages of the disease. Just before death there may be hyperpyrexia and the temperature may fall to subnormal, although death may occur without either of these changes.

Parasites may as a rule be found by microscopic examination throughout the course of the disease. In not a few cases, however, there are intermissions of short duration; and in one case we found parasites only once in daily examinations for seven days, though the blood was infectious by animal experiment during this time.

Œdema as a rule is not a prominent symptom, but is sometimes noticeable about the face and genitals. Anæmia is rapid and severe, but the emaciation is not so great as that observed in other animals. Some interference with the gait is occasionally noticed, but it is neither constant nor very severe. Gastro-intestinal changes are absent in most cases, but diarrhea is sometimes noticed toward the end.

Necropsy shows the general lesions seen in other animals. In addition to the evidence of severe anæmia, the most constant changes are an enlarged, mottled spleen, enlarged lymphatics, fluid in the serous cavities, and flakes of fibrin over the surfaces of the organs.

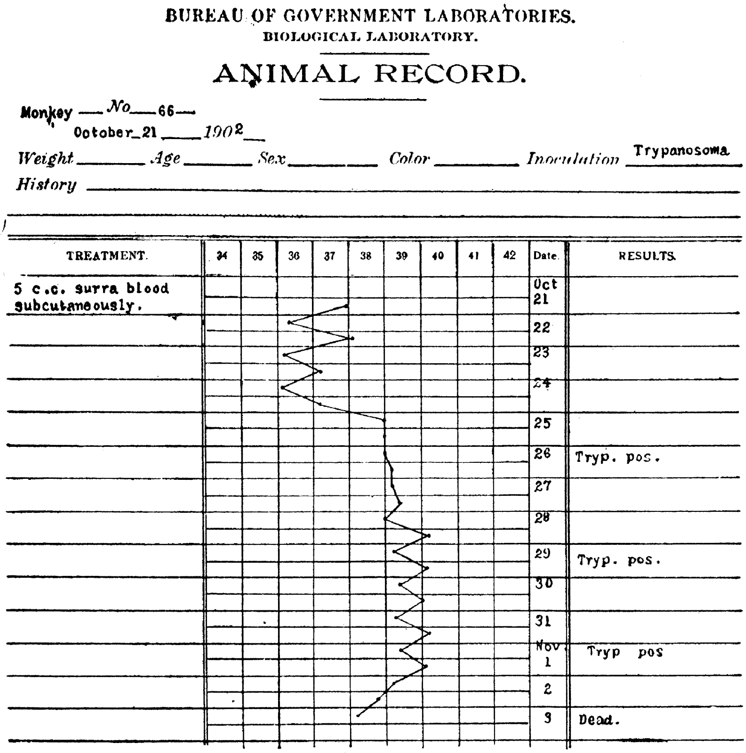
TRYPANOSOMIASIS OF DOGS.

Dogs are susceptible to surra in India and show the same general symptoms as those seen in other animals. The incubation period is short and the course rapid.

Lingard mentions as the principal symptoms paroxysmal fever (figs. 119, 133), anorexia, later a swelling of the skin about the head and throat, injection of the conjunctiva, increased lachrymation, in some cases effusions into the joints, marked œdema of the limbs and the belly, extravasation of the blood into the anterior chambers, opacity of the cornea, and later total blindness. He gives as the principal anatomic lesions subpleural extravasations and sometimes localized consolidation of the lungs, enlarged spleen and kidneys, with subcapsular petechiæ.

Rouget proved dogs susceptible to dourine. The symptoms were œdema, particularly marked in the genitals, paralysis of the hind quarters, and conjunctivitis, sometimes followed by keratitis.

Dogs, according to Voges, contract mal de caderas by eating the flesh of animals dead of the disease, not, however, through the sound mucosa, but through injuries,



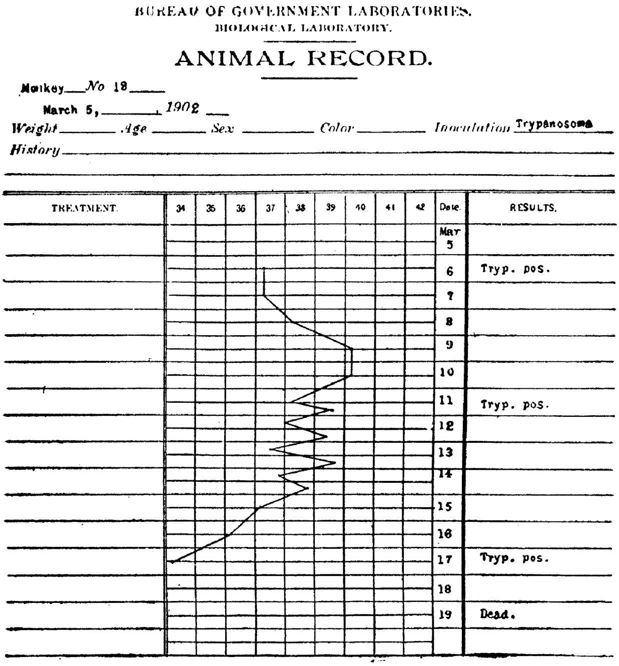
BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Monkey — No — 66 —
October 21 ____ 1902 __
Weight ____ Age ____ Sex ____ Color ____ Inoculation Trypanosoma
History ____

TREATMENT.	34	35	36	37	38	39	40	41	42	Date.	RESULTS.
5 c.c. surra blood subcutaneously.										Oct 21	
										22	
										23	
										24	
										25	
										26	Tryp. pos.
										27	
										28	
										29	Tryp. pos.
										30	
										31	
										Nov 1	Tryp pos
										2	
										3	Dead.

FIG. 130.—Temperature record of surra in a monkey.



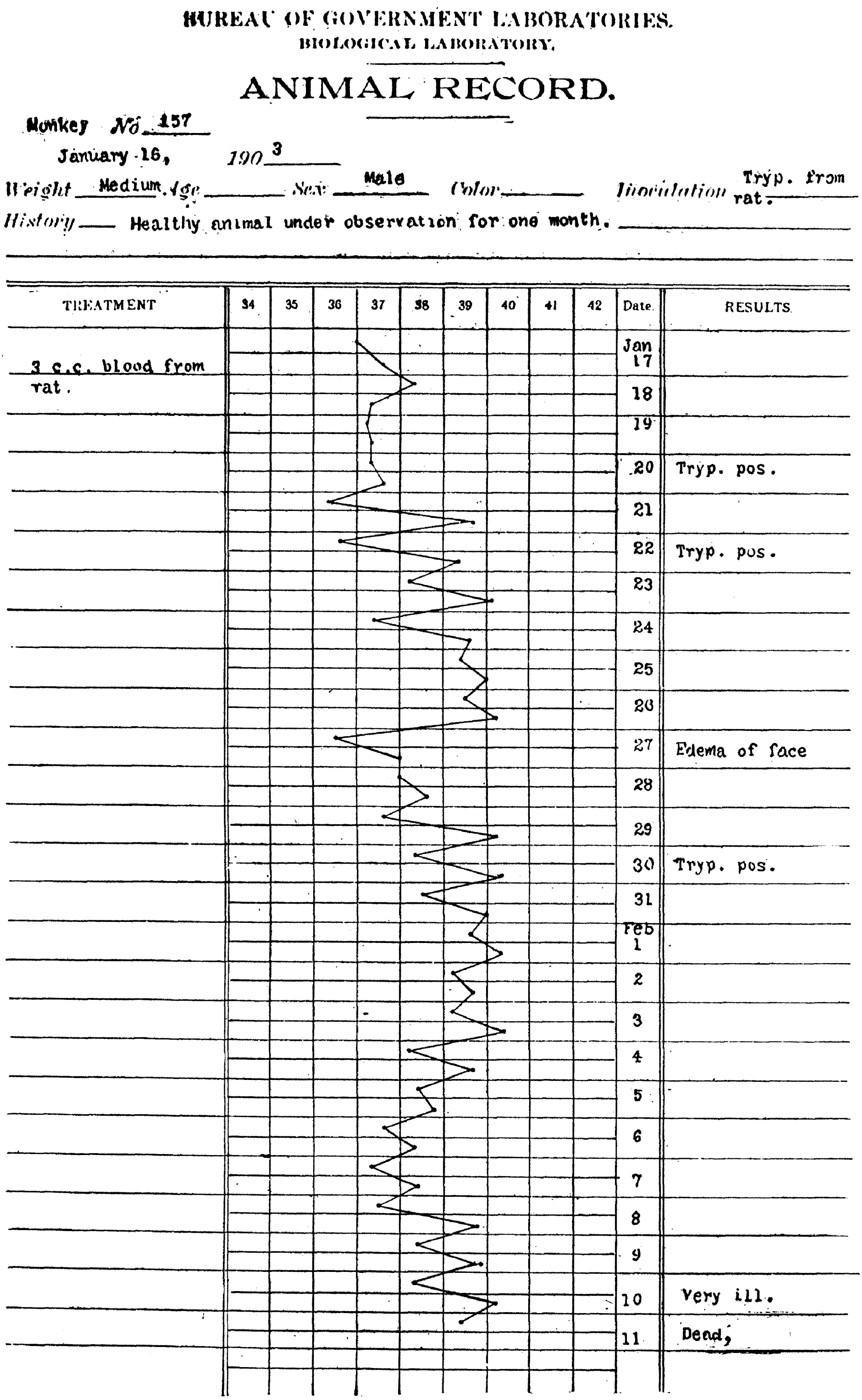
BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Monkey __ No 18 ____
March 5, ____ 1902 __
Weight ____ Age ____ Sex ____ Color ____ Inoculation Trypanosoma
History ____

TREATMENT.	34	35	36	37	38	39	40	41	42	Date.	RESULTS.
										Mar 5	
										6	Tryp. pos.
										7	
										8	
										9	
										10	
										11	Tryp. pos.
										12	
										13	
										14	
										15	
										16	
										17	Tryp. pos.
										18	
										19	Dead.

FIG. 131.—Temperature record of surra in a monkey.



BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Monkey No. 157

January 16, 1903

Weight Medium. Age ______ Sex Male Color ______ Inoculation Tryp. from rat.

History Healthy animal under observation for one month.

TREATMENT	Date	RESULTS
3 c.c. blood from rat.	Jan 17	
	18	
	19	
	20	Tryp. pos.
	21	
	22	Tryp. pos.
	23	
	24	
	25	
	26	
	27	Edema of face
	28	
	29	
	30	Tryp. pos.
	31	
	Feb 1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	Very ill.
	11	Dead.

FIG. 132.—Temperature record of surra in a monkey.

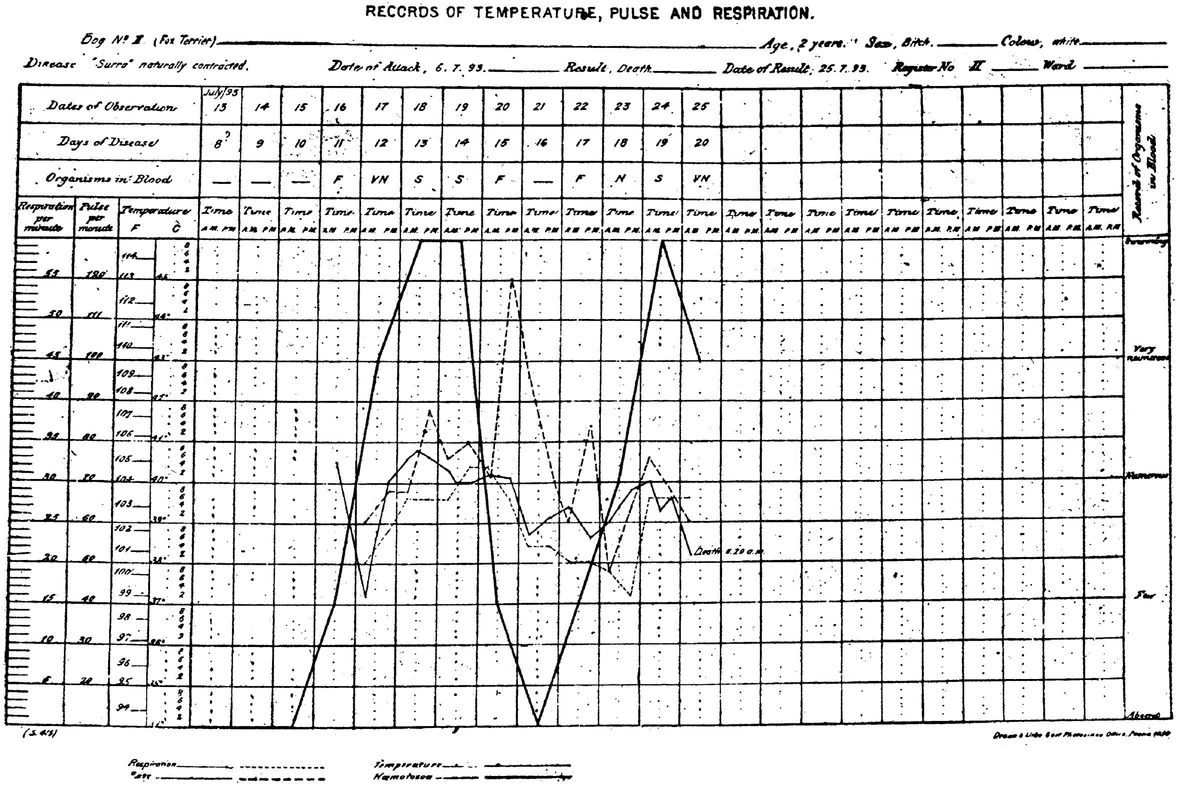


FIG. 133.—Temperature record of surra in a dog (Lingard.)

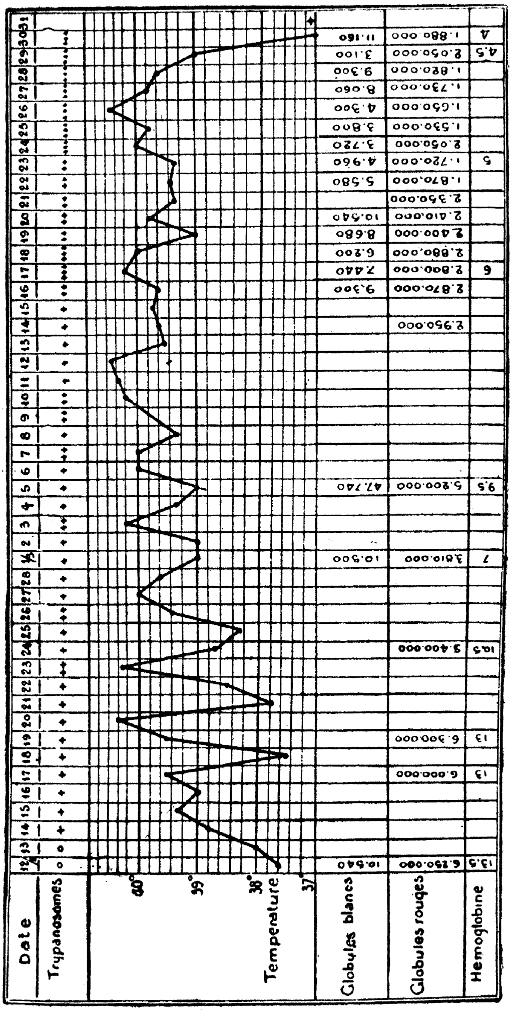


FIG. 134.—Temperature record of dog inoculated February 12, 1902, intravenously with ½ c. c. of rat's blood very rich in Trypanosoma. Dead in 48 days. (After Lignieres, in Recueil d. Med. Vet. Vol. 10, No. 4, Feb. 28, 1903, p. 131.)

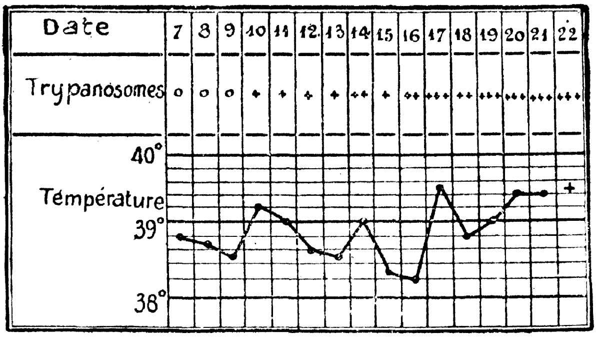
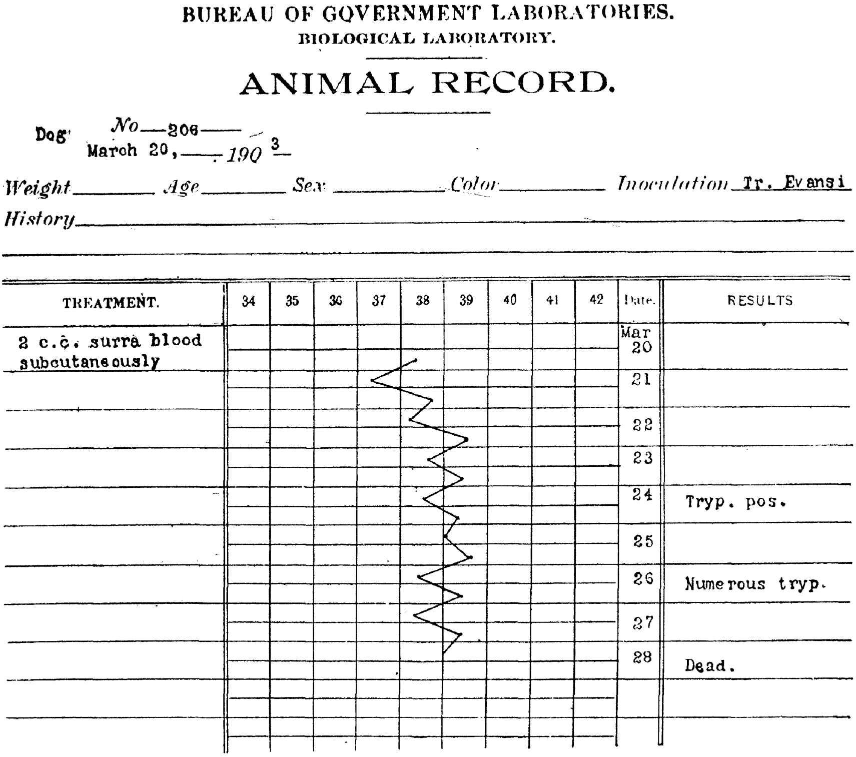


FIG. 135.—Temperature record of surra in a dog. Inoculated on January 6, 1901, subcutaneously with 1¼ c. c. of blood from Dog No. 2, containing from 3 to 4 parasites in the microscopic field. Dead in 16 days. (After Lignieres, in Recueil d. Med. Vet. Vol. 10, No. 4, February 28, 1903, p. 130.)



BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Dog No—208—
March 20, 190 3

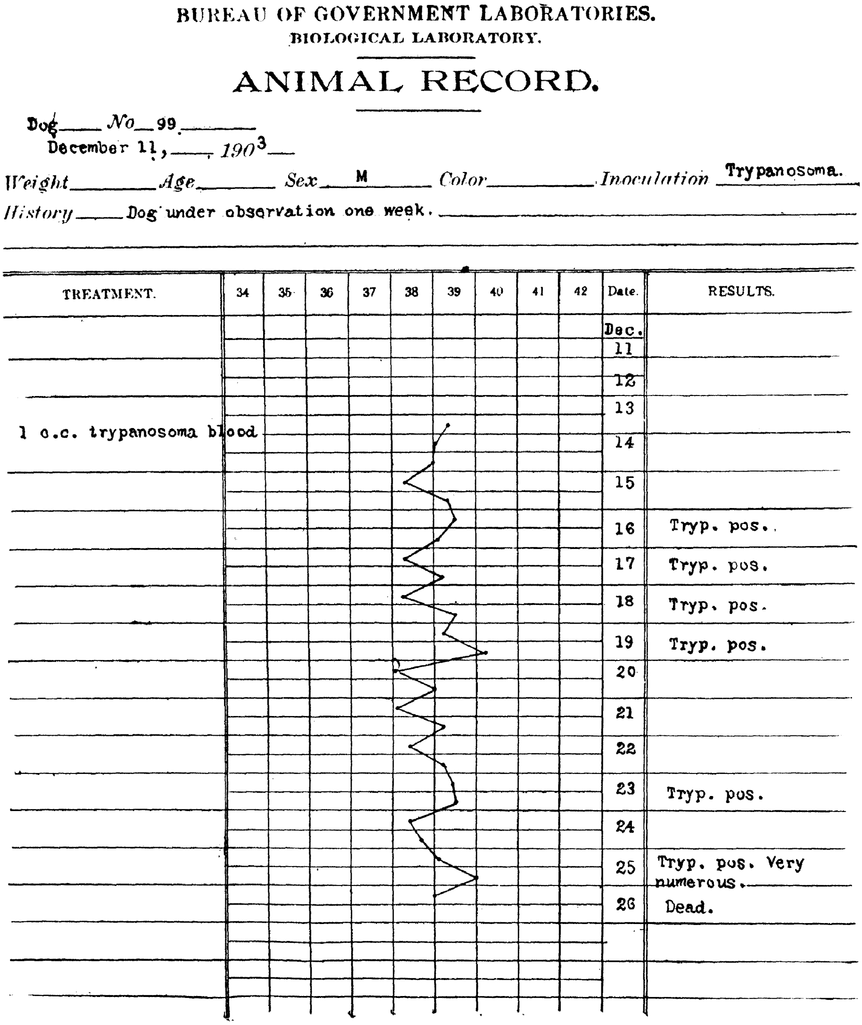
Weight ____ Age ____ Sex ____ Color ____ Inoculation Tr. Evansi

History ____

TREATMENT.	Date.	RESULTS
2 c.c. surra blood subcutaneously	Mar 20	
	21	
	22	
	23	
	24	Tryp. pos.
	25	
	26	Numerous tryp.
	27	
	28	Dead.

34
35
36
37
38
39
40
41
42

FIG. 136.—Temperature record of surra in a dog.



BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Dog No 99
December 11, 1903
Weight Age Sex M Color Inoculation Trypanosoma.
History Dog under observation one week.

TREATMENT.	34	35	36	37	38	39	40	41	42	Date.	RESULTS.
										Dec.	
										11	
										12	
										13	
1 c.c. trypanosoma blood										14	
										15	
										16	Tryp. pos.
										17	Tryp. pos.
										18	Tryp. pos.
										19	Tryp. pos.
										20	
										21	
										22	
										23	Tryp. pos.
										24	
										25	Tryp. pos. Very numerous.
										26	Dead.

FIG. 137.—Temperature record of surra in a dog.

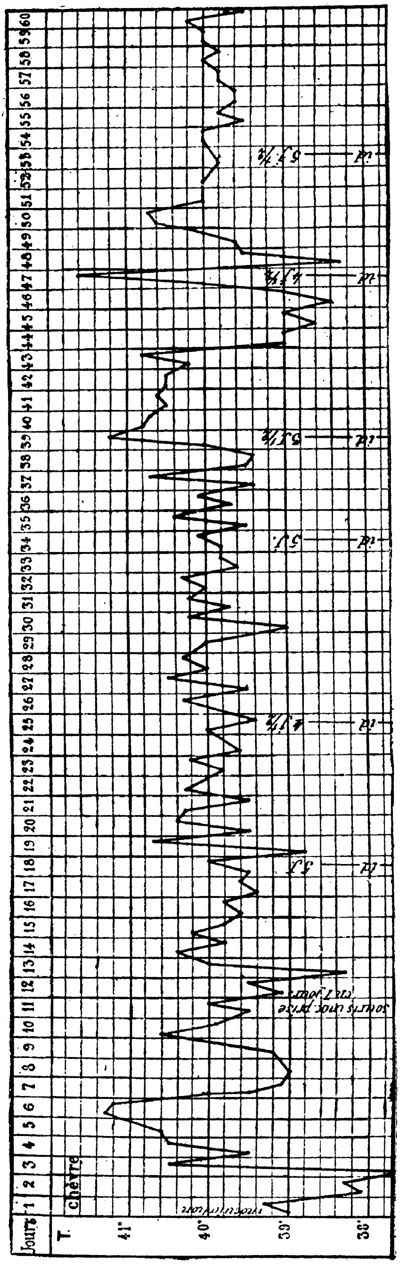


FIG. 139.—Nagana in a goat. (After Laveran and Mesnil, 1902, fig. 5.)

which are always found to be present on examination and are caused by fighting. The incubation period is short and the duration of the illness varies from two to three months.

He describes the symptoms as follows:

"The animal becomes stupid, emaciates, no longer responds when called, sleeps, hides in dark corners, and its head becomes swollen (bulldog appearance) as a result of the œdema, which affects particularly the eyelids. The conjunctiva are involved to a pitiful extent and secretions similar to those seen in the rabbit are observed. The hair about the eyes falls out. The vision is likewise impaired by the chronic conjunctivitis. There is marked œdema of the scrotum, which is first revealed by the swelling of the testicles. * * * The penis is not involved. On section enlarged spleen and serous exudates are observed. * * * There are days when *Trypanosoma* are not found in the blood."

Nagana, according to Bruce, has a rapid course in these animals (eight to sixteen days) and is invariably fatal. He mentions as the principal symptoms continuous fever (rarely intermittent) with elevations to 40° and 41° C., extreme emaciation, pustular eruptions near the extremities, and a milky aspect of the cornea.

Kanthuck, Durham, and Blandford give the period of incubation as from four to six days and the average duration of the disease as eighteen days. Fever is a constant symptom, the temperature becoming subnormal near death. Œdema is common and more marked about the head, legs, belly, and genitalia. Turbidity of the aqueous humor, fibrinous plaques in the anterior chamber, and corneal opacities are occasionally seen. Corneal ulcers and conjunctivitis are frequently associated with the œdema of the eyelids and face. Parasites may be absent from the blood from four to six days, but continue to increase in number and before death may reach 100,000 to 300,000 per cubic millimeter. Terminal bacterial infections are apt to occur in these animals, thus accelerating death.

Anatomically muscular wasting is well marked, but the fatty tissues are less affected, except at the base of the heart, where the fat may undergo œdematous degeneration. Lymphatic hyperplasia is well marked, the glands being congested or hemorrhagic. The spleen is enlarged, granular, firm, and friable. Serous effusions and subserous hemorrhages are present.

Laveran and Mesnil state that the virus was frequently more active in their experience than in that of others. Their dogs lived from six and one-half to twelve days. The incubation period from subcutaneous inoculation varied between two and four days. Parasites could always be demonstrated to be present in the blood by microscopic examination, and from the time of their first appearance until death they usually increased in number; but in the dogs which lived for twelve days there were remissions on the eighth and ninth days, followed by augmentation. Parasites were always numerous at the time of death.

The principal symptoms, according to these authors, are œdema of the genital organs and hypertrophy of the inguinal lymphatics, although these symptoms may be absent. Less frequently œdema of the head and slight and transient paresis of the posterior extremities may occur. Important lesions of the nose and eyes are found only occasionally. The temperature rises on the third to the fifth day and usually remains above 40° C. until death. Considerable loss of weight is constantly observed.

In the Philippines dogs are very susceptible to surra by inoculation, and we have thus far observed two which contracted the disease naturally. Owing to their susceptibility and the ease with which an unlimited supply of the animals may be obtained for experimental work, they have been used in large numbers in the present investigation.

The incubation period is from four to seven days, the course is rapid, being from eight to twenty-four days in length, and the mortality is 100 per cent.

The temperature (figs. 122–124, 136–138) varies considerably, but is usually remittent and rarely runs as high as in some other species of animals. Death may occur with hyperpyrexia, but more usually it is preceded by a drop of the temperature to normal or subnormal.

The animals rarely live long enough for anæmia and emaciation to become extreme, but both are very noticeable from the beginning. In dogs the appetite, as a rule, is very poor, although there are exceptions in which it is ravenous throughout the entire course of the disease. The bowels remain normal.

The "bulldog head," produced by the subcutaneous œdema about the face, occurs to a varying degree, which depends somewhat upon the length of time the animal lives. Œdema of the scrotum and belly is also present, but sometimes where the course is very rapid it may scarcely be noticeable.

Urticarial eruptions on various parts of the body are hardly a prominent symptom; they do occur, however, and occasionally are very marked. As in other animals the hair becomes rough and falls out; this is especially true of the eyelashes and the long hairs about the nose.

Catarrhal symtoms, accompanied by watery discharges from the nose and eyes, are noticed early, and later become severe. The discharges become muco-purulent and acrid, excoriating the sides of the nose. Clouding of the fluid in the anterior chamber is of frequent occurrence and may lead to total blindness. Partial deafness also occurs. In many cases the partial paralysis of the hind quarters seen in other animals is also observed. Parasites as a rule are constantly present in the blood from the time of their first appearance until death. Post-mortem examinations show lesions closely resembling the ones found in other animals.

TRYPANOSOMIASIS OF GOATS.

This species of animals is apparently not susceptible to natural infection, and on inoculation the disease runs so chronic a course that some authors consider them immune. The duration and the mortality do not appear to be well defined.

Rost says that goats inoculated with surra blood have fever, but soon recover, and subsequent doses do but very little harm. They are refractory to the disease, and parasites are not generally found in the blood.

Voges considers them susceptible to mal de caderas by inoculation and says the disease lasts for several months. The animals at first show no symptoms, and often do not do so for months; but emaciation finally begins and death is usually sudden. *Trypanosoma* are periodically absent from the blood.

Bruce considers goats susceptible to nagana by inoculation, but says that the disease runs a chronic course, often lasting for several months.

Laveran and Mesnil inoculated a goat with *Tr. brucei*, and it was still alive at the time of publication of their article, three months later. They say that the beginning of the disease in these animals is much the same as in horses, the incubation period being from three to eight days, followed by a rise of temperature to about 41° C. Parasites are only temporarily present, and are not again found, but the blood continues to be infectious by inoculation.

In our experience goats have always proved susceptible by inoculation. Parasites are usually scarce in the peripheral circulation, and indeed in some of our animals were not found at any time during the disease; but the blood was always infectious by inoculation, and the disease invariably proved fatal.

The incubation period varies in length, and is difficult to determine accurately without daily animal experiment. The temperature curve is illustrated in figs. 126–128, 140–142, and does not show anything characteristic, nor does it differ much from that of other species of animals. Neither emaciation nor anæmia are marked. Œdema is never prominent, and may be entirely absent. Paresis of the hind parts was observed in only one of our animals.

Goats manifest their illness by preferably lying in the shade, and by the listlessness and sluggishness of their movements. They seem to suffer some pain, just as is the case with monkeys.

Post-mortem examination reveals nothing characteristic, the lesions closely resembling those observed in other animals.

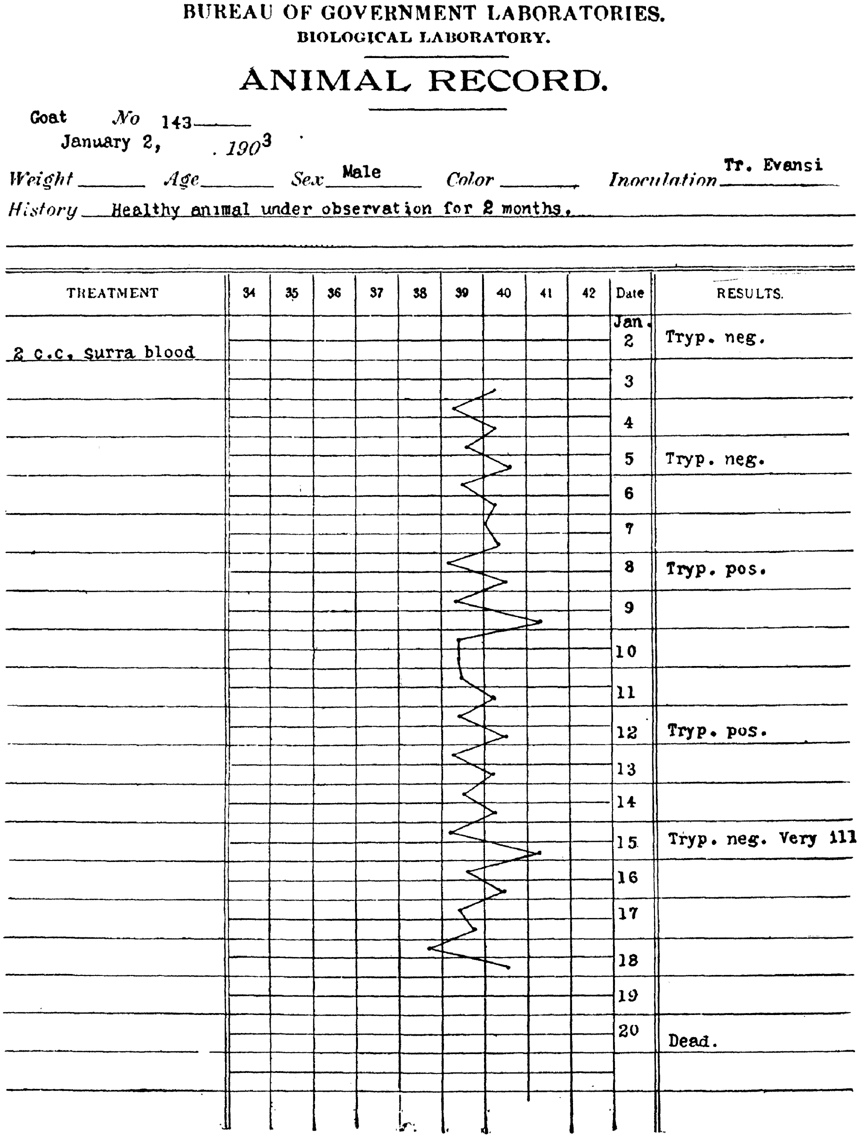
TRYPANOSOMIASIS OF SHEEP.

Most authors writing of surra, nagana, dourine, and mal de caderas regard the nature of the disease in these animals as very similar to that in goats. The sheep of eastern Africa are considered by Bruce to be somewhat refractory. The disease in these animals, he says, runs a very chronic course, and some of them live for five months.

Laveran and Mesnil inoculated a sheep with *Tr. brucei*, and in an article published three months later stated that it was still living. They consider the beginning of the disease much the same as in horses. There is generally an incubation period of three days, followed by the appearance of parasites and an elevation of the temperature to 41° C. *Trypanosoma* then become so rare that they are not found in the blood by microscopic examination, although the blood is constantly infectious when injected into mice. The temperature remains near 40° C., with occasional intermissions, although it sometimes rises to 41° C.

Regarding one sheep, which lived exactly one hundred and ninety-seven days, they write as follows:

"On the sixth day after inoculation it showed a temperature of about 41° C., which shortly afterwards fell to between 39° and 40° C.; on the twenty-fourth day there was another rise to 41.5° C., after which the temperature remained for a long



BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Goat *No* 143
January 2, *1903*

Weight ______ *Age* ______ *Sex* Male *Color* ______ *Inoculation* Tr. Evansi

History Healthy animal under observation for 2 months.

TREATMENT	34	35	36	37	38	39	40	41	42	Date	RESULTS.
2 c.c. surra blood										Jan. 2	Tryp. neg.
										3	
										4	
										5	Tryp. neg.
										6	
										7	
										8	Tryp. pos.
										9	
										10	
										11	
										12	Tryp. pos.
										13	
										14	
										15	Tryp. neg. Very ill
										16	
										17	
										18	
										19	
										20	Dead.

FIG. 141.—Temperature record of surra in a goat.

BUREAU OF GOVERNMENT LABORATORIES.

BIOLOGICAL LABORATORY.

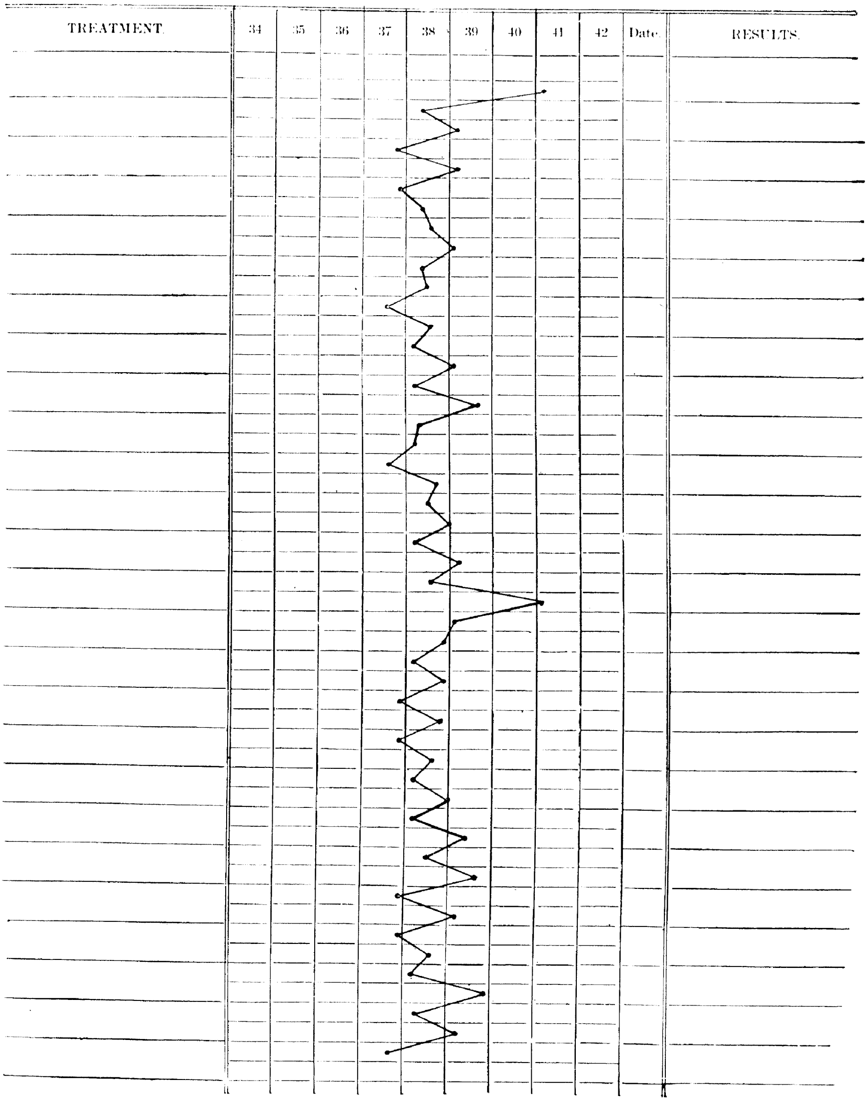
ANIMAL RECORD.

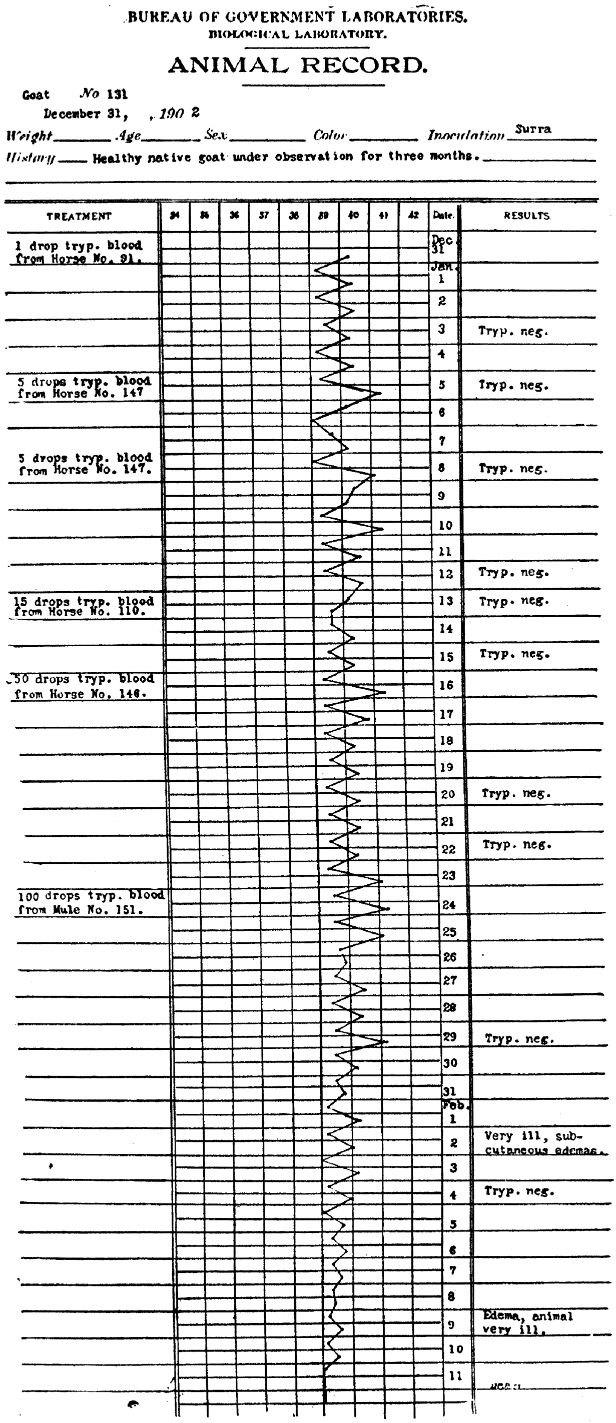
Carabao No. 48

June 7 1903 190

Weight 900 *Age* 15 *Sex* Male *Color* Black *Inoculation* Rinderpest

History from Shanghai





BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Goat No 131
December 31, 1902
Weight _____ Age _____ Sex _____ Color _____ Inoculation Surra
History Healthy native goat under observation for three months.

TREATMENT	Date.	RESULTS.
1 drop tryp. blood from Horse No. 91.	Dec. 31	
	Jan. 1	
	2	
	3	Tryp. neg.
	4	
5 drops tryp. blood from Horse No. 147	5	Tryp. neg.
	6	
	7	
5 drops tryp. blood from Horse No. 147.	8	Tryp. neg.
	9	
	10	
	11	
	12	Tryp. neg.
15 drops tryp. blood from Horse No. 110.	13	Tryp. neg.
	14	
	15	Tryp. neg.
50 drops tryp. blood from Horse No. 146.	16	
	17	
	18	
	19	
	20	Tryp. neg.
	21	
	22	Tryp. neg.
	23	
100 drops tryp. blood from Mule No. 151.	24	
	25	
	26	
	27	
	28	
	29	Tryp. neg.
	30	
	31	
	Feb. 1	
	2	Very ill, subcutaneous edemas.
	3	
	4	Tryp. neg.
	5	
	6	
	7	
	8	
	9	Edema, animal very ill.
	10	
	11	dead

FIG. 142.—Temperature record of a goat repeatedly inoculated with *Tr. evansii;* paraeites not found by microscopic examination.

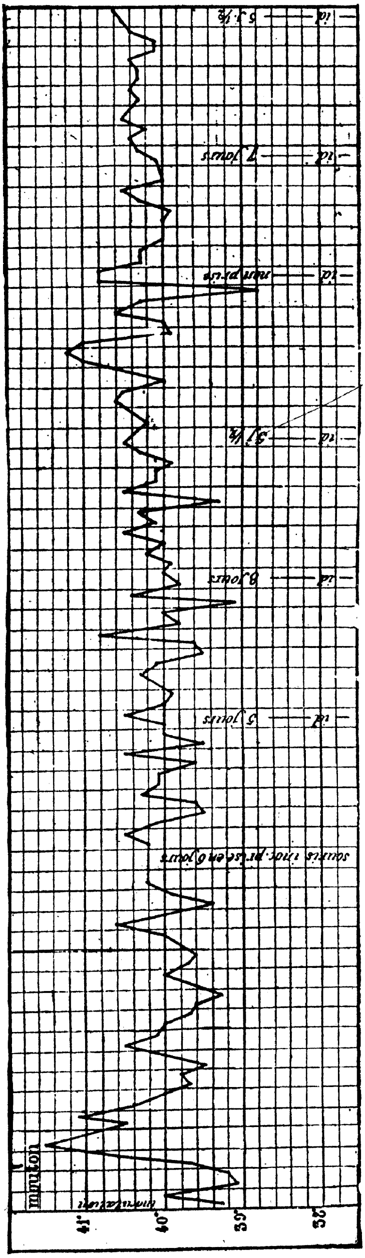


FIG. 143.—Surra in sheep. (After Laveran and Mesnil, 1902, fig. 6.)

BUREAU OF GOVERNMENT LABORATORIES.

BIOLOGICAL LABORATORY.

ANIMAL RECORD.

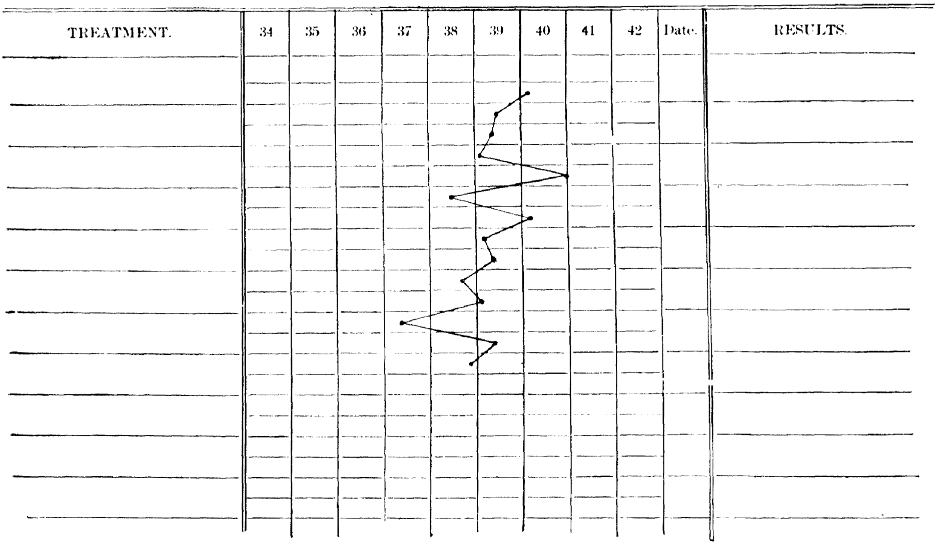
Carabao *No.* 7

Case I.

June 2, *190*3.

Weight 900 *Age* 15 *Sex* Male *Color* Black *Inoculation* Rinderpest

History from Shanghai



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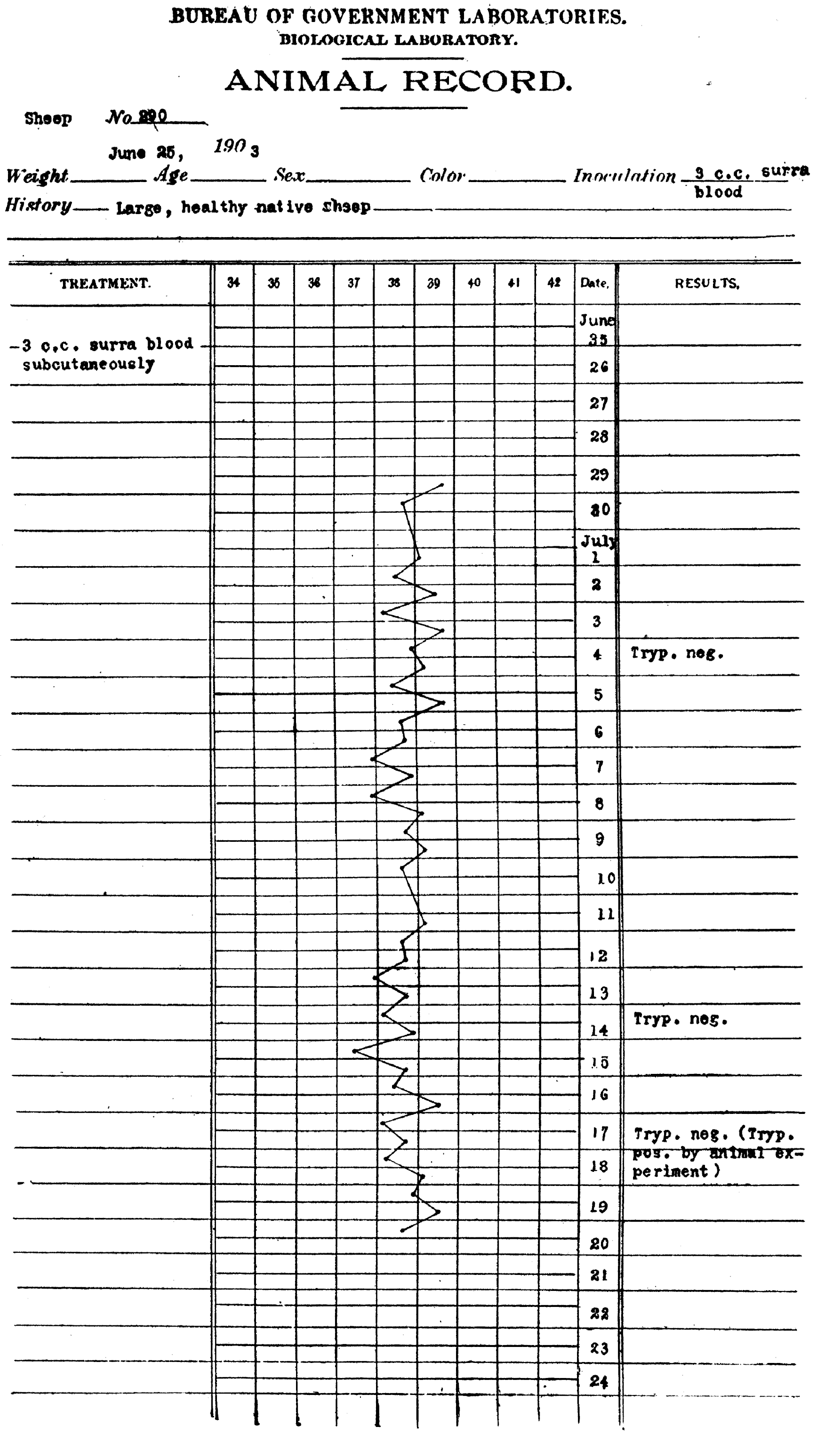


BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Sheep *No* 890

June 25, *190*3

Weight _____ *Age* _____ *Sex* _____ *Color* _____ *Inoculation* 3 c.c. surra blood

History — Large, healthy native sheep

TREATMENT.	34	35	36	37	38	39	40	41	42	Date.	RESULTS.
-3 c.c. surra blood subcutaneously										June 25	
										26	
										27	
										28	
										29	
										30	
										July 1	
										2	
										3	
										4	Tryp. neg.
										5	
										6	
										7	
										8	
										9	
										10	
										11	
										12	
										13	
										14	Tryp. neg.
										15	
										16	
										17	Tryp. neg. (Tryp. pos. by animal experiment)
										18	
										19	
										20	
										21	
										22	
										23	
										24	

FIG. 144.—Temperature record of surra in a sheep.

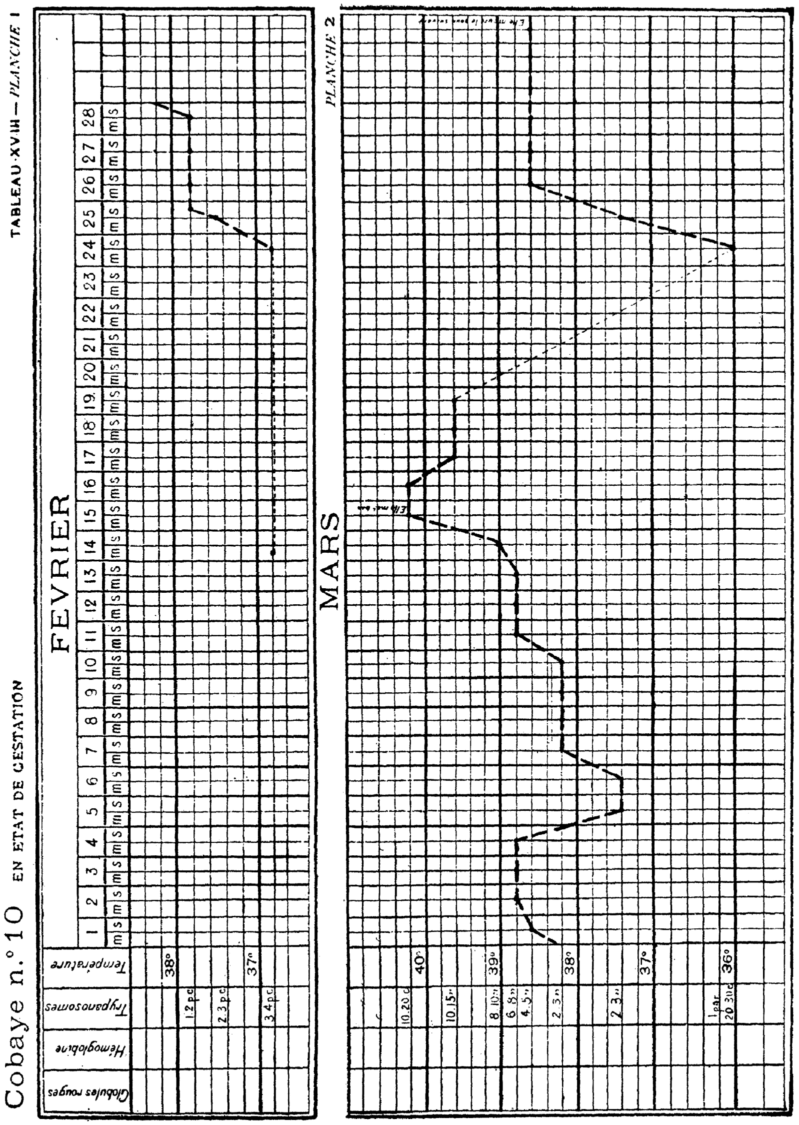
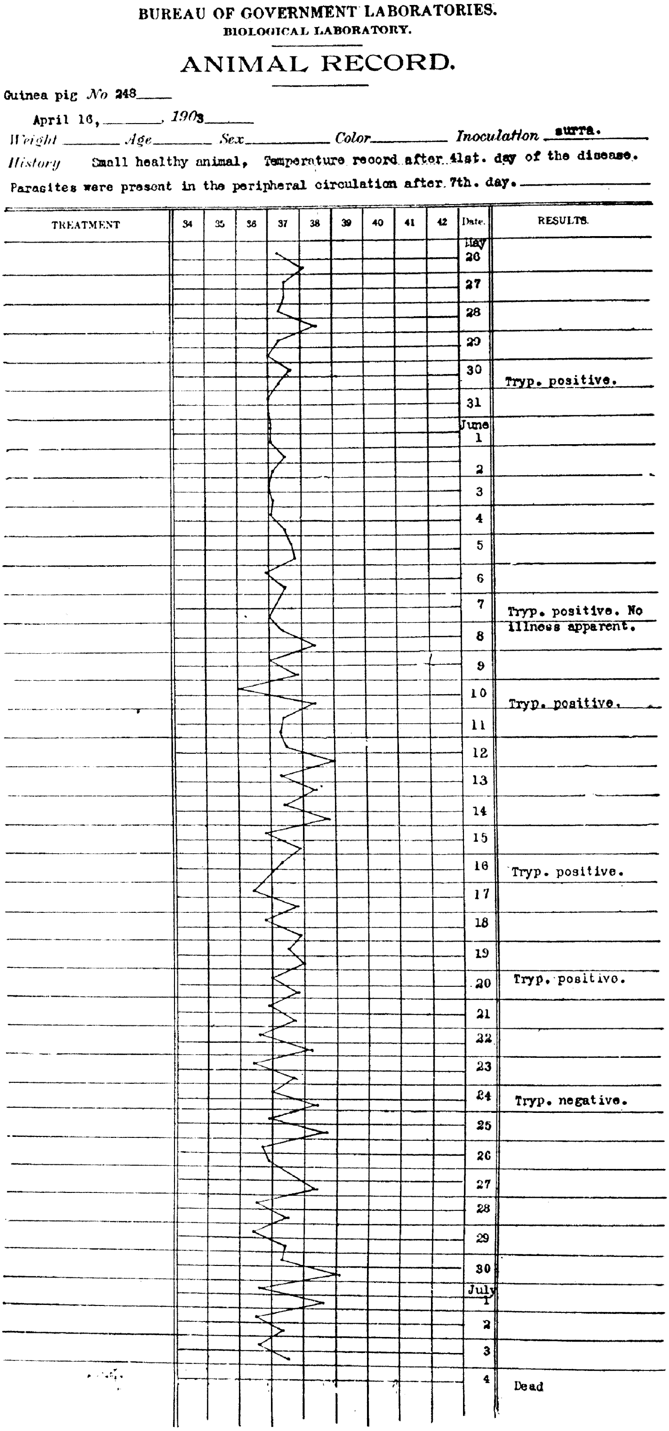


FIG. 145.—Temperature record of mal de caderas in a guinea pig. (After Sivori and Lecler, 1902, pl. 18.)



BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Guinea pig *No* 248

April 16, *19*03

Weight *Age* *Sex* *Color* *Inoculation* surra.

History Small healthy animal, Temperature record after 41st. day of the disease. Parasites were present in the peripheral circulation after 7th. day.

Date.	RESULTS.
May 30	Tryp. positive.
June 7	Tryp. positive. No illness apparent.
June 10	Tryp. positive.
June 16	Tryp. positive.
June 20	Tryp. positive.
June 24	Tryp. negative.
July 4	Dead

FIG. 146.—Temperature record of surra in a guinea pig.

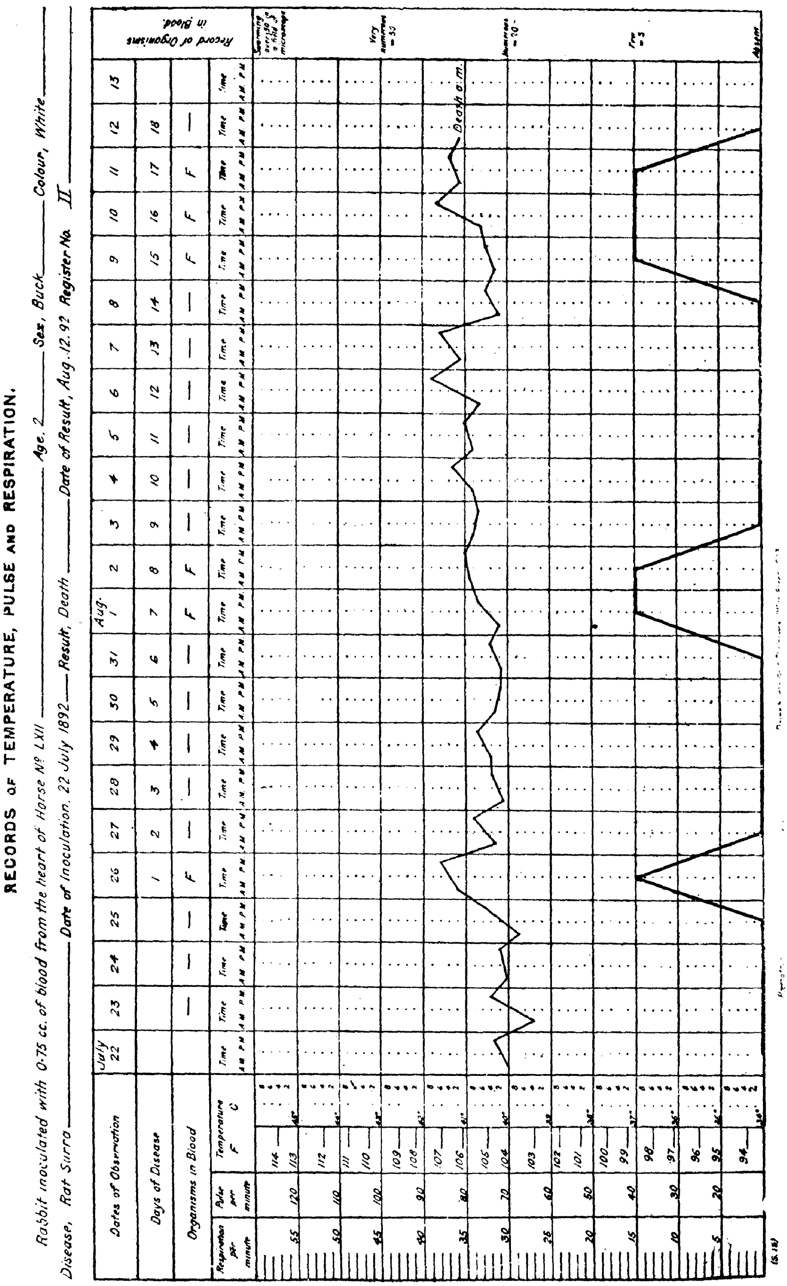
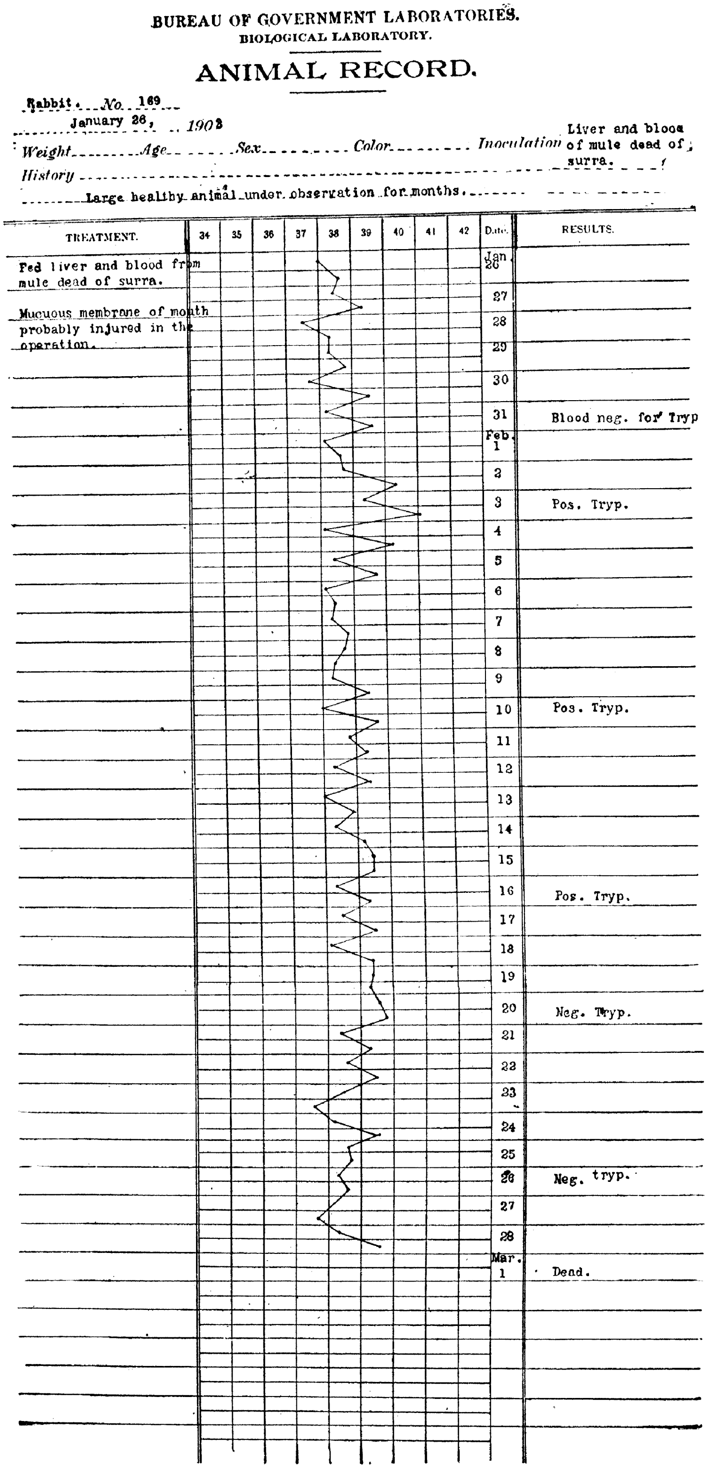


FIG. 147.—Temperature record of surra in a rabbit. (After Lingard.)



BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Rabbit. No. 169

January 26, 1903

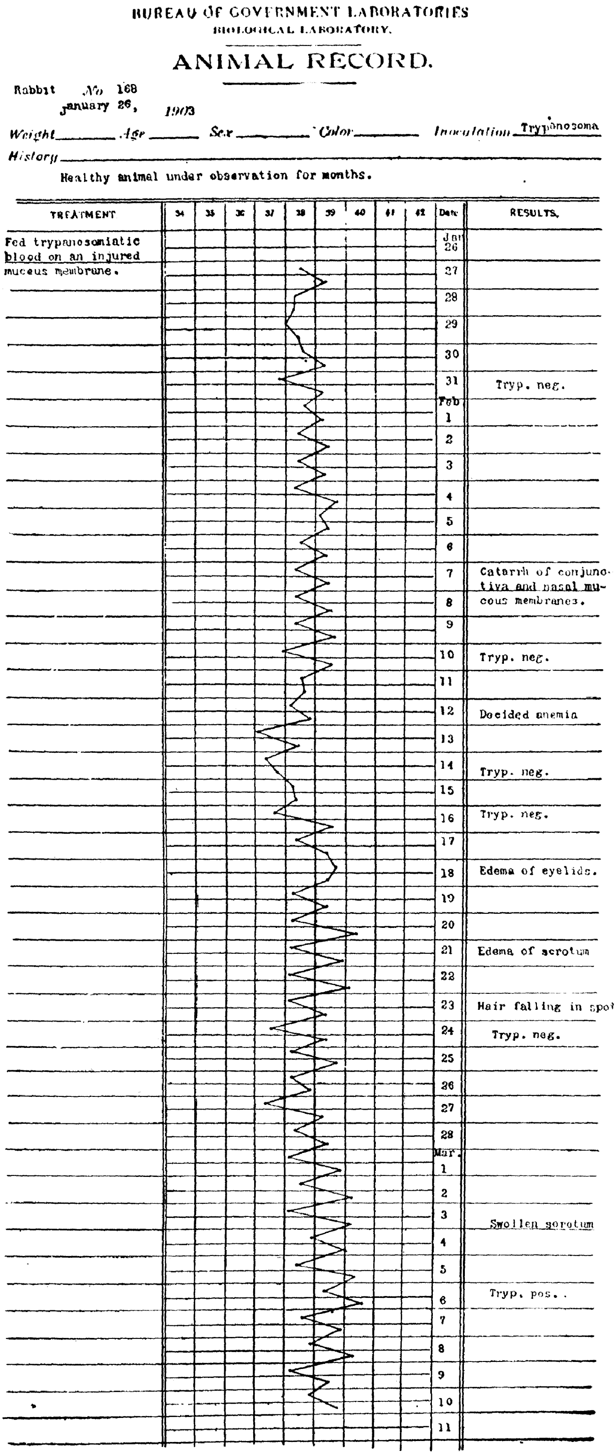
Weight Age Sex Color Inoculation Liver and blood of mule dead of surra.

History

Large healthy animal under observation for months.

TREATMENT.	34	35	36	37	38	39	40	41	42	Date.	RESULTS.
Fed liver and blood from mule dead of surra.										Jan 26	
										27	
Mucuous membrane of mouth probably injured in the operation.										28	
										29	
										30	
										31	Blood neg. for Tryp
										Feb. 1	
										2	
										3	Pos. Tryp.
										4	
										5	
										6	
										7	
										8	
										9	
										10	Pos. Tryp.
										11	
										12	
										13	
										14	
										15	
										16	Pos. Tryp.
										17	
										18	
										19	
										20	Neg. Tryp.
										21	
										22	
										23	
										24	
										25	
										26	Neg. tryp.
										27	
										28	
										Mar. 1	Dead.

FIG. 148.—Temperature record of surra in a rabbit.



BUREAU OF GOVERNMENT LABORATORIES
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Rabbit No 168
January 26, 1903

Weight ______ Age ______ Sex ______ Color ______ Inoculation Trypanosoma

History ______

Healthy animal under observation for months.

TREATMENT	34	35	36	37	38	39	40	41	42	Date	RESULTS.
Fed trypanosomiatic blood on an injured										Jan 26	
muceus membrane.										27	
										28	
										29	
										30	
										31	Tryp. neg.
										Feb 1	
										2	
										3	
										4	
										5	
										6	
										7	Catarrh of conjunctiva and nasal mu-
										8	cous membranes.
										9	
										10	Tryp. neg.
										11	
										12	Decided anemia
										13	
										14	Tryp. neg.
										15	
										16	Tryp. neg.
										17	
										18	Edema of eyelids.
										19	
										20	
										21	Edema of scrotum
										22	
										23	Hair falling in spo
										24	Tryp. neg.
										25	
										26	
										27	
										28	
										Mar. 1	
										2	
										3	Swollen scrotum
										4	
										5	
										6	Tryp. pos..
										7	
										8	
										9	
										10	
										11	

FIG. 140.—Temperature record of surra in a rabbit.

time in the neighborhood of 41° C., taking thirty days to return to 40° C.; multiple œdematous areas appeared in the face and eyes and then in the testicles. It was only during this period that *Trypanosoma* could be found by microscopic examination, and for eight days there were several in the field. The œdema increased and extended to the neck and shoulders (end of the third month). Its disappearance was rapid; the animal (during the fourth and fifth months and the first half of the sixth) appeared well, the temperature being between 39° and 40° C., but the blood was still virulent. During the last month the animal emaciated rapidly and died with profound lesions of cachexia and gelatinous exudates of the throat, the pericardium, and the lips.''

As with some of the other animals, neither the study nor the discription of the infection in sheep is as accurate as might be desired for purposes of comparison. In the Philippine Islands they do not appear to be naturally susceptible to the disease. We have kept a sheep in the same ground with surra animals for several months, but no infection has resulted.

The symptoms, the course, and the duration of the disease in these animals are so similar to those observed in the goat that a description of them is considered unnecessary.

TRYPANOSOMIASIS OF GUINEA PIGS.

There are on record a few instances in which guinea pigs have been found naturally infected with *Trypanosoma*, but literature affords little detailed study of any of the forms of the disease in these animals. It is admitted that they are susceptible by inoculation to *Tr. evansii*, *Tr. brucei*, and *Tr. elmassianii*, while some of them show a transient infection from *Tr. lewisii*.

Laveran and Mesnil noticed multiplication forms on the second and fifth days after inoculating one of these animals in the abdominal cavity with *Tr. lewisii*. Many of the parasites in the abdominal cavity were in various stages of digestion by the large mononuclear leucocytes. There were a few *Trypanosoma* in the blood on the fifth and seventh days.

Sivori and Lecler give sixty days as the average duration of *surra americain* in these animals, although it varies from twenty-five to one hundred and sixty days. In pregnant females parasites are more numerous than in other cases and almost constantly present.

Voges says that one-half to two-thirds of these animals when inoculated with mal de caderas die of the disease, the duration of the disease in those which finally succumb being from two to five months. He has some guinea pigs that have been alive for a year, have grown fat, and have had young. The generative power of the male suffers from the infection more than does that of the female.

We have succeeded, as did Laveran and Mesnil, in producing a slight infection with *Tr. lewisii*, but it is always transient and devoid of symptoms.

Guinea pigs do not naturally contract any form of trypanosomiasis in this country, but when inoculated with the *Trypanosoma* of the present epidemic always show a long chronic infection.

As nearly as can be determined, the incubation period varies from two to eleven days. The duration of the disease is from one to four months, and but few animals recover from it.

The appearance of parasites in the circulating blood is very intermittent but always in sufficient numbers for microscopic diagnosis, although the blood is constantly infectious by animal experiment. Sometimes parasites are not found by the usual microscopic technique for days and even weeks.

The temperature curve (see fig. 132, 146) is very irregular, more so than in any other class of animal with which we have worked. The symptoms in general resemble those of the rabbit. Œdema of the genitals is marked, but in the rest of the body is less prominent than in the case of other animals. Anæmia and emaciation develop slowly, but reach an extreme degree before death. The hair falls out in places and small ulcers may appear on the belly and the prepuce or vulva. Partial paralysis of the hind parts occurs but is not constant, being absent in some cases while well marked in others.

Post-mortem examination reveals a condition similar to that observed in many other animals. There is as a rule less fluid than is ordinarily found in the serous cavities of other animals, and the changes in the spleen are often slight. The gelatinous infiltrations in the subserous and subcutaneous tissues closely resemble those seen in the horse.

TRYPANOSOMIASIS OF RABBITS.

Rabbits are susceptible by inoculation to all the important forms of trypanosomiasis, but we have read of no reported cases of natural infection in these animals.

Rouget very irregularly found the parasites in the blood of rabbits suffering from dourine, but their presence in the peripheral circulation was intermittent and bore no relation to the temperature of the animals. As the principal symptoms he gives œdema of the ears, falling out of the hair, paralysis of the hind parts, mucous conjunctivitis, which later becomes purulent, and œdema of the genitals. The duration of the disease is from one to four months. The principal anatomic lesions are hyperæmia of the abdominal layers, inflammation of the spleen and liver and of the lymphatics near the point of inoculation.

Mal de caderas, according to Voges, lasts for one to three months in these animals. Parasites may not be found in the blood for the first four weeks. The rabbits remain active for weeks, but toward the end emaciation is apparent. The fever is very irregular. Catarrhal conjunctivitis supervenes, becoming purulent and causing the lids to adhere to each other. The hairs of the eyelids always drop out, and sight finally becomes greatly impaired. Inflammation of the nose occurs, causing the hairs to stick and fall out. The testicles swell, but the penis is unaffected. *Trypanosoma* are found in the inflamed testicles and vulva, and on necropsy, indeed in all parts of the body. The spleen is enlarged and serous exudates are always observed.

Sivori and Lecler, working with the *surra americain* of South America, say that parasites may be found in the blood eight hours following intraperitoneal inoculation, and that the duration of the disease is from sixteen to one hundred and sixteen days. The disease is characterized by emaciation, tumefaction of the eyelids, purulent blefero-conjunctivitis, and marked œdema of the nose, penis, and vulva. The temperature is irregular and without relation to the number of parasites in the circulating blood.

Kanthuck, Durham, and Blandford regard the rabbit as relatively immune to nagana. They say that the incubation period is from five to seven days, and the duration from twenty to one hundred and eighty-three days, the average being about fifty.

Laveran and Mesnil consider it to be a susceptible animal. The incubation period is from two to four days, and the duration of the disease from fifteen to thirty, although death sometimes occurs in five to six days. Parasites appear in the peripheral circulation intermittently. When the disease lasts twenty days or more, conjunctivitis sets in and the hair about the eyelids falls out; œdema of the vulva or prepuce and forelegs occurs, but the lesions are always slight. During the whole course of the disease the rabbit has a continuous temperature, with rare intermissions; it is generally above 40° C.

In this country rabbits have not been found naturally infected. They are susceptible by inoculation and afford most interesting subjects for the study of the disease. Fig. 133, 147 illustrates the course of surra in these animals, as given by Lingard.

The incubation period is difficult to determine accurately for the reason that, contrary to the results obtained from many animals, it is not, as a rule, followed by a sharp rise of temperature and the appearance of parasites in the blood, a fact which probably accounts for the great variations in the length of time assigned to it. In fact, there does not appear to be a distinct incubation period in all cases, for in some cases animal experiment may prove the blood infectious as early as eight hours after inoculation, while in others it does not become so until the fourth or fifth day. The course of the disease is somewhat chronic, lasting from fifteen days to three months or more, with a mortality of 100 per cent.

It is seldom that parasites are numerous in the peripheral circulation, and determinations by simple microscopic examinations show that intermissions are frequent, lasting from one or two days to several weeks, during which parasites are not found. As in other animals, however, the blood is continuously infectious by animal inoculation. The temperature (see figs. 134–135, 148–149) throughout the disease is less markedly remittent than is usual in most animals, while exacerbations and remissions are rare.

Anæmia and emaciation come on rather slowly, but develop to an extreme degree before death. Watery discharges from the nose and eyes appear early, gradually becoming muco-purulent and tenacious, solidifying on the margins of the eyelids and nose and incrusting and entangling the long hairs, which fall out and leave excoriated surfaces. (See fig. 136, 150.) Œdema occurs around the base of the ears, the nose, and the abdomen, involving especially the scrotum, which becomes enormously distended and may break open and suppurate. (See fig. 137, 151.) There is a discharge from the prepuce similar to that from the eyes and nose. In the female the

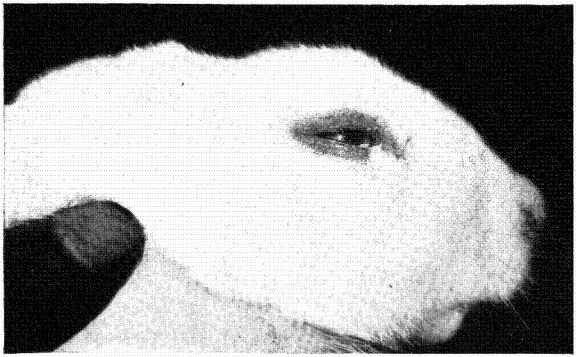


FIG. 150.—SHOWING MUCO-PURULENT DISCHARGE FROM EYES, FALLING OF LONG HAIRS, BLEPHARITIS AND CONJUNCTIVITIS IN RABBIT.

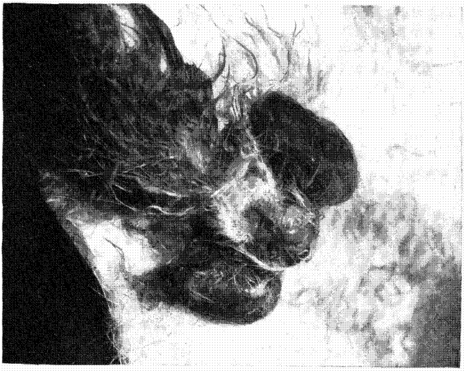


FIG. 151.—SHOWING ENORMOUS SWELLING OF GENITALS IN RABBIT WITH SURRA.

external genitals are scarcely less affected than in the male. Urticarial eruptions and falling out of the hair are common symptoms. Lameness of the hind parts occurs in most cases, and may reach such a degree that the posterior extremities become useless. The subcutaneous lymphatics are often palpable, and in some instances swelling of the joints occurs.

Necropsy reveals lesions similar to those observed in other animals. The lymphatics, particularly of the inguinal and postperitoneal regions, are somewhat enlarged and red in color. The serous sacs contain fluid and often show fibrinous flakes over the surfaces and adjacent organs. The spleen is usually enlarged and friable, but a typical acute splenic tumor is often seen, while "sago spleen" occasionally occurs.

TRYPANOSOMIASIS OF CATS.

Cats are reported susceptible by inoculation to surra, nagana, dourine, and mal de caderas, but the course of the disease does not seem to have been carefully studied in them. Fig. 152 illustrates the course of the temperature in surra, as given by Lingard. Fig. 153 that of "surra americain," as given by Sivori and Lecler.

In the Philippine Islands they are susceptible to the infection by any of the usual forms of inoculation. The incubation period is from two to five days, the course rapid, varying from three to fifteen days, and the mortality 100 per cent.

Parasites are constantly present in the blood, but vary considerably in numbers at different times. The temperature curve is illustrated in figs. 154–155.

Skin lesions in these animals are very prominent and are similar to those described for dourine. Urticarial and macular eruptions are common, and not a few animals show phlegmanous ulcers, particularly on the abdomen and flanks. Œdema is slight.

The hair, particularly about the nose and eyes, becomes rough and falls out. Profuse discharges from the nose and eyes, resembling those in the case of the rabbit, are a usual symptom. Cloudiness of the fluid in the anterior chamber and opacity of the cornea may occur in one or both eyes. Anæmia is profound and emaciation moderate. The appetite is usually poor, but the bowels remain normal. Tendency to paralysis in the hind quarters was noticed in only one animal.

Necropsy reveals the usual lesions, in addition to the changes already mentioned as present during life. The acuteness of the disease in these animals probably accounts for the fact that the lesions are less pronounced. The spleen is enlarged, but assumes more nearly the type of acute splenic tumor, while subserous hemorrhages are numerous.

TRYPANOSOMIASIS OF RATS AND MICE.

Tr. lewisii, the common *Trypanosoma* of rats, has already been described. Most writers agree that it is harmless for rats and noninfectious, by inoculation or otherwise, for other animals.

Large numbers of rats have been found naturally infected in various parts of the world; a partial list of the regions is as follows: Lewis, in Calcutta, found 29 per cent infected; in Bombay, Carter found 12 per cent infected and Lingard 30 per cent; Koch, in Africa, 41.7 per cent; Crookshank, in London, 25 per cent; Rabinowitsch and Kempner, in Berlin, 41.8 per cent; Laveran and Mesnil, in Paris, 4.6 per cent; Baillet, in Alfort, a large percentage; Chemette, at Lille, a large percentage; Sivori and Lecler, at Buenos Ayres, 3 per cent, and Chalachnikow and Danilewsky, in Russia, found the infection present. In Togo eight rats examined were negative (Luman). Voges, in South America, did not find these animals naturally infected. In a personal letter Kitasato, in Japan, states that many of the rats there harbor the parasite.

In Manila rats *Tr. lewisii* has been found in from 20 to 65 per cent of the individuals examined, varying according to the season and the locality from which they were received.

Van Dyke Carter inoculated dogs, cats, horses, and monkeys with rat *Trypanosoma* and always obtained negative results. Koch failed permanently to transfer the infection to other animals. He gave a rat *Tr. lewisii* and *Tr. evansii* and afterwards found both in its blood. He then inoculated a dog with some of this rat's blood, and the animal contracted the disease, but its blood was found to contain only *Tr. evansii*. The efforts of Rabinowitsch and Kempner to inoculate other animals with *Tr. lewisii* proved unsuccessful. In their experiments they used white and gray mice, field mice, guinea pigs, rabbits, dogs, goats, horses, and hamsters.

Lingard, on the other hand, inoculated twelve horses with infected rat blood, and four of them, after an average of seven days, died of a virulent form of surra. He argues that some *Tr. lewisii* are infectious for other animals, as demonstrated by his experiments. This statement has caused considerable confusion, and his work has

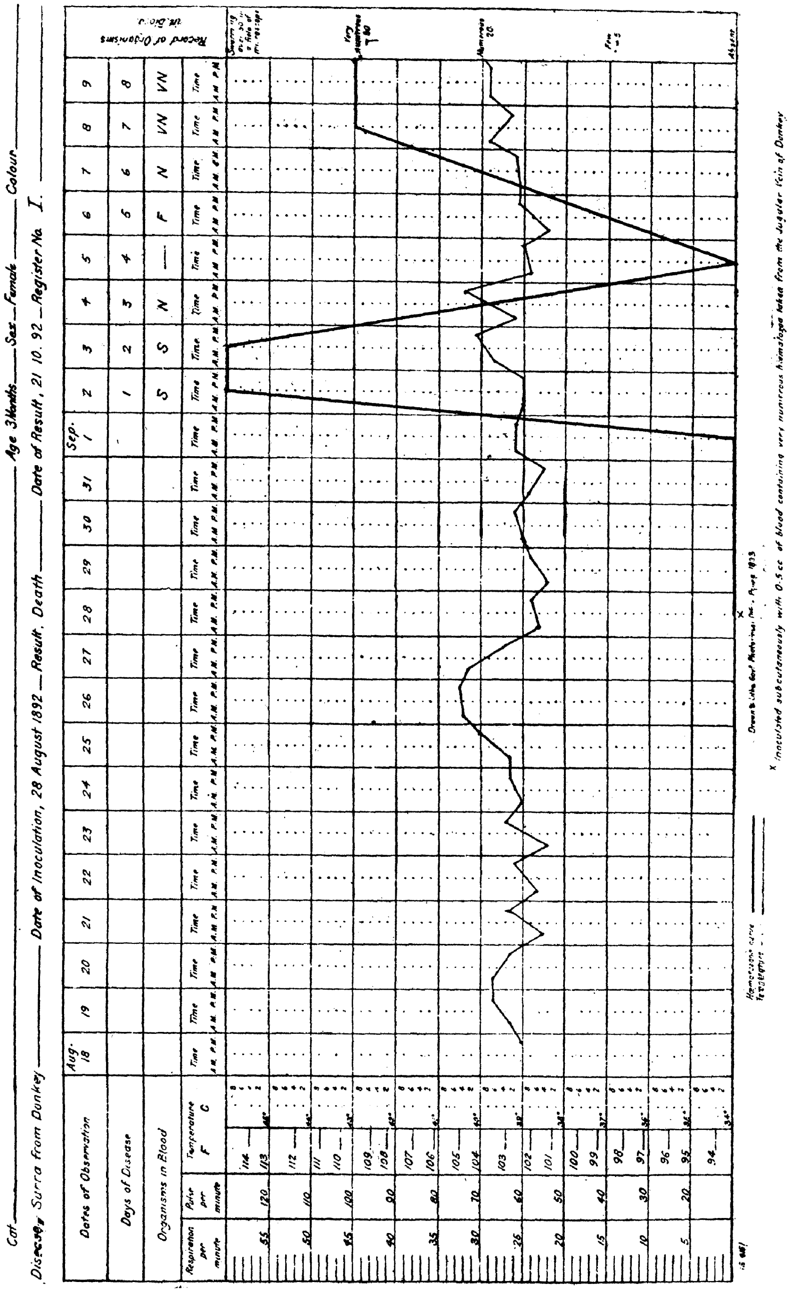


FIG. 152.—Temperature record of surra in a cat. (After Lingard.)

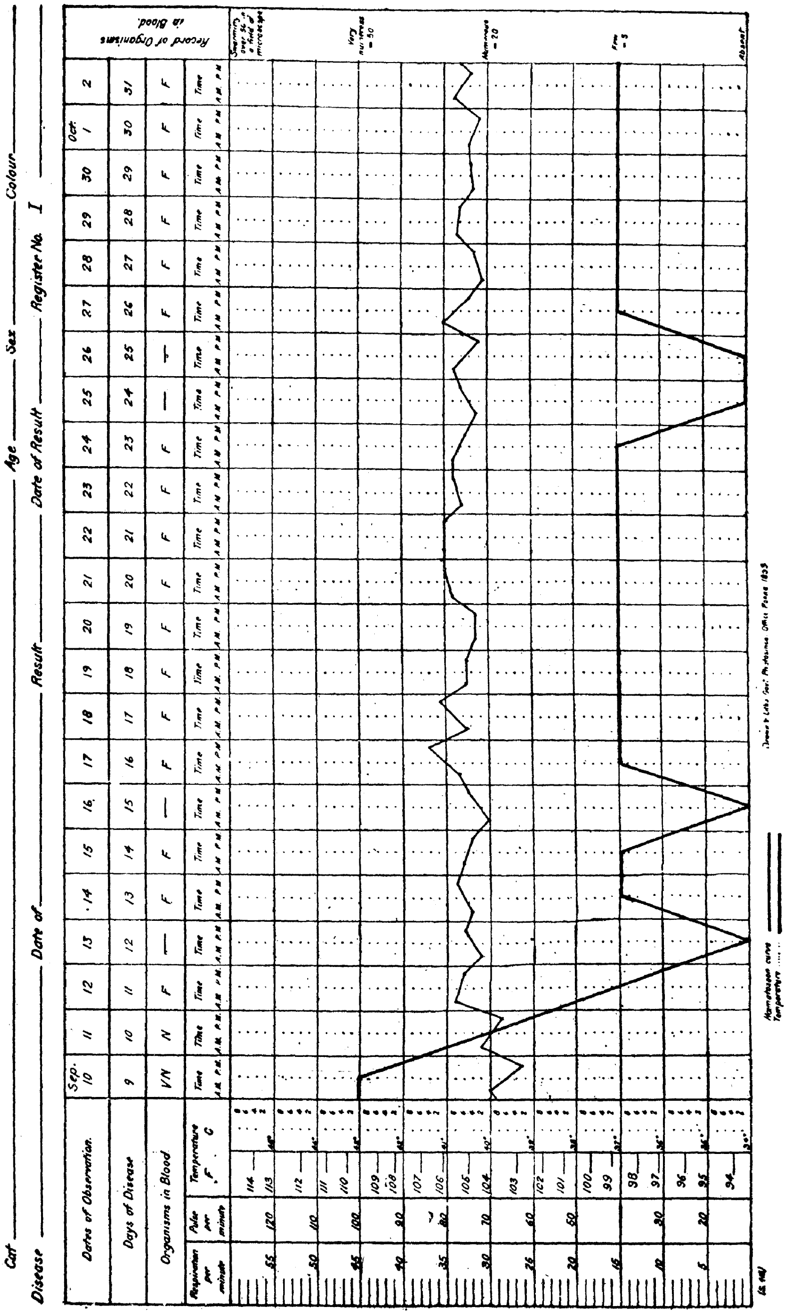


FIG. 152—Continued.

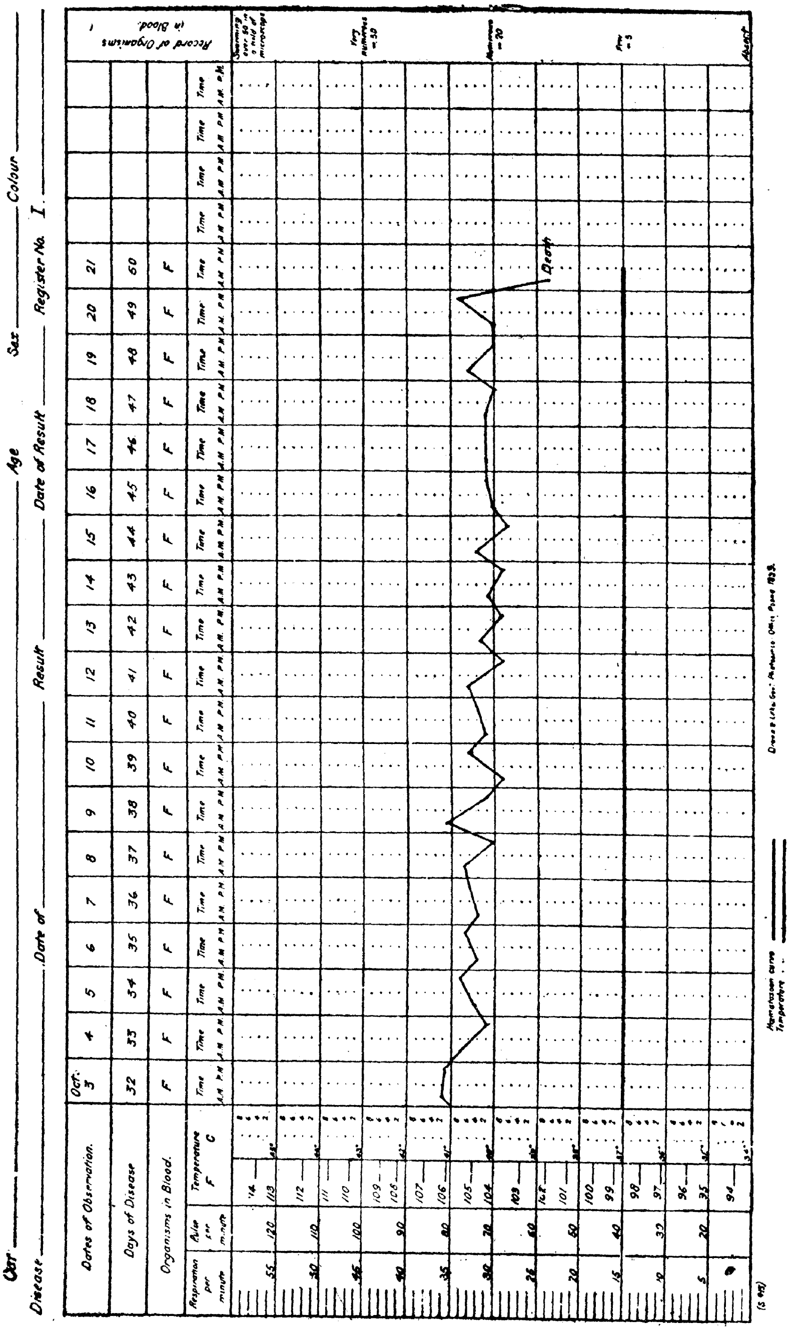


FIG. 152—Continued.

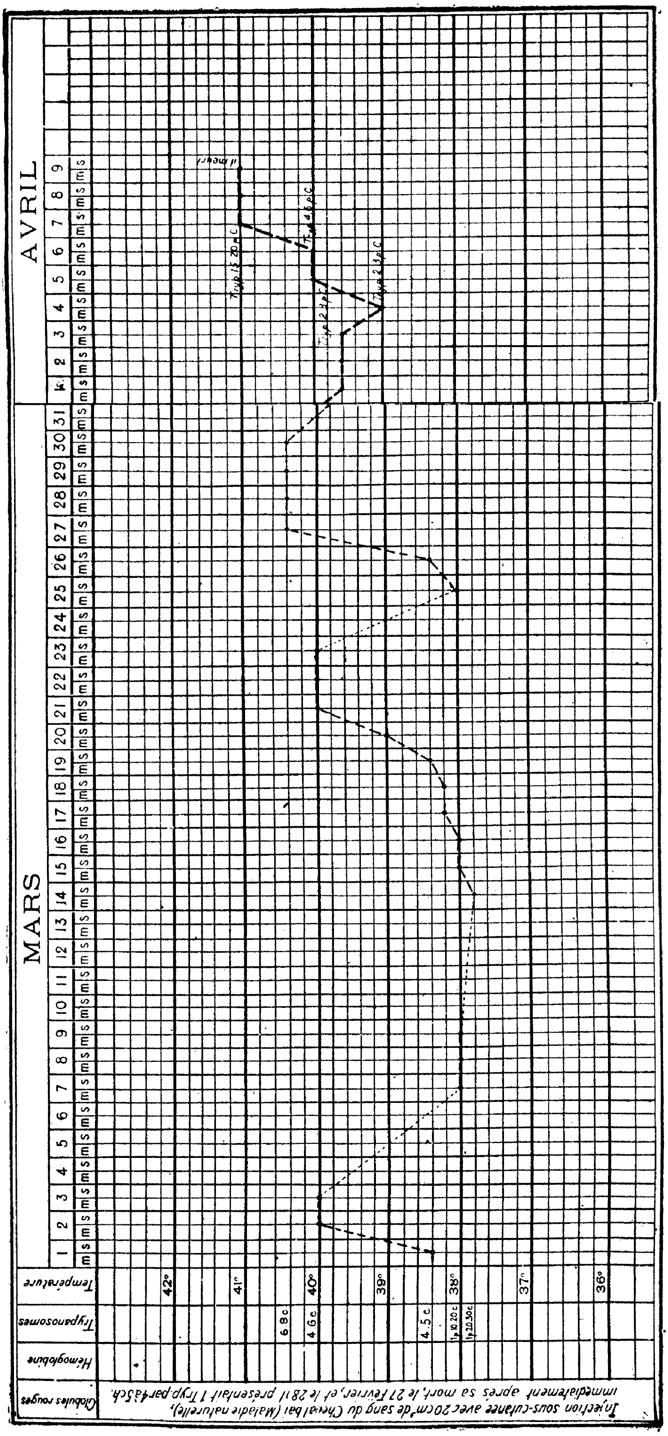
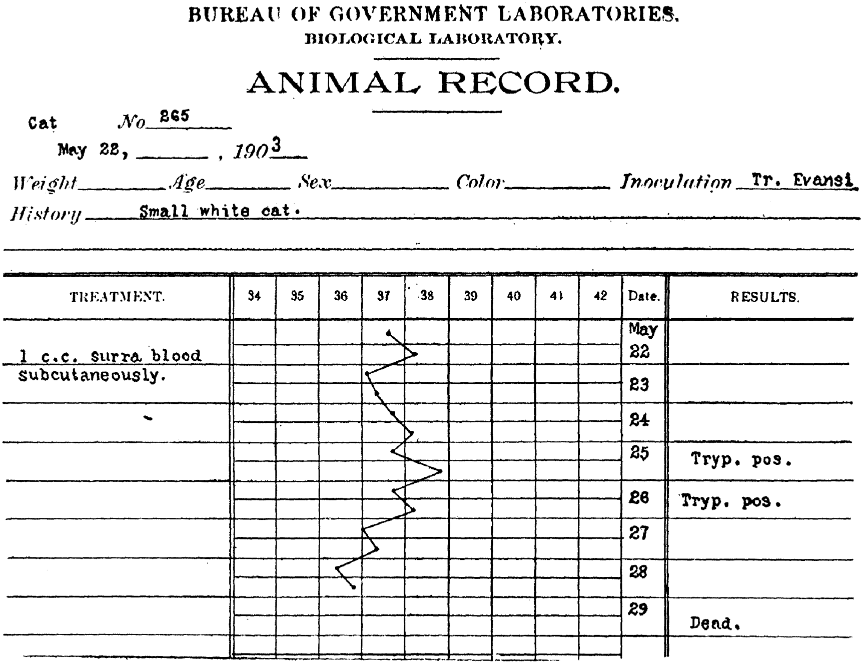


FIG. 153.—"Surra americain" of cat. (After Sivori and Lecler, 1902. Pl. XX, pt. 1.)

been questioned. Judging from our observations in Manila, it would appear, however, that Lingard's mistake consisted in considering these pathogenic parasites *Tr. lewisii.*

Kanthuck, Durham, and Blandford showed rats to be refractory to a second inoculation with *Tr. lewisii.* Rabinowitsch and Kempner noticed that some rats are absolutely refractory to these parasites, but that most of them are susceptible. After inoculations into the abdominal cavity *Trypanosoma* were found to be present in the blood after from three to seven days, and occasionally at the end of twenty-four hours. In rats inoculated in the abdominal cavity they found multiplication forms to be numerous in the exudate during twenty-four to thirty-six hours, at the end of which they disappeared permanently from the abdominal cavity to reappear in the blood. Rats could not be given a second infection, no matter how large the dose of infected blood used; and they employed the important fact that some of the animals are refractory as a basis for the preparation of a specific serum.

Laveran and Mesnil in general confirmed Rabinowitsch and Kempner's work and in addition showed that the young born of immune mothers are very slightly if at all immune. They also demonstrated that the agglutinating properties of the blood are not transferred to young. In immune rats *Trypanosoma* are destroyed in the abdominal cavity, and the agglutinative power of the blood lasts no longer than the preventive. In their opinion the treatment of rats with serum is unsucessful. They state that as a rule the parasites appear in the blood at the end of twenty-four hours, and that in not a few cases, especially in young rats, they are found in considerable numbers before this time. However, many cases came under their observation in which the parasites did not appear in the blood until two to seven days after inoculation, and indeed in a few instances no infection resulted at all.



BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

ANIMAL RECORD.

Cat *No.* 265
May 22, ______, *190*3
Weight ______ *Age* ______ *Sex* ______ *Color* ______ *Inoculation* Tr. Evansi
History Small white cat.

TREATMENT.	34	35	36	37	38	39	40	41	42	Date.	RESULTS.
1 c.c. surra blood subcutaneously.										May 22	
										23	
										24	
										25	Tryp. pos.
										26	Tryp. pos.
										27	
										28	
										29	Dead.

FIG. 154.—Temperature record of surra in a cat.

Adult parasites are the first to be seen in the blood, then there is a period, rarely extending beyond the eighth day, when multiplication forms may be observed, after which adult parasites are visible throughout the course of the disease. They believe multiplication to take place in the abdominal cavity during the period from the first to the fourth day, and in the blood between the fourth and the eighth days, after which time multiplication forms are no longer present.

Infection of these animals with *Tr. lewisii* lasts from twenty days to four months or more. In old ones the *Trypanosoma* often disappear in two to ten days, and in these no active immunity is established. Subcutaneous inoculations, according to these authors, give infections which are less severe than those produced by other methods.

BUREAU OF GOVERNMENT LABORATORIES.
BIOLOGICAL LABORATORY.

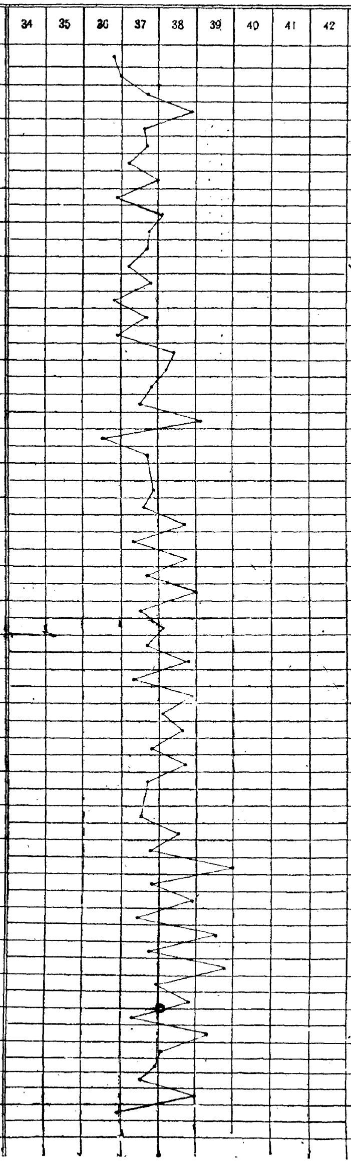
ANIMAL RECORD.

Cat *No* 266

May 26, *190* 3

Weight ______ *Age* ______ *Sex* ______ *Color* ______ *Inoculation* Surra.

History Medium-sized healthy cat.



TREATMENT	Date.	RESULTS.
1 c.c. surra blood subcutaneously	May 26	
	27	
	28	
	29	
	30	Tryp. pos.
	31	
	June 1	
	2	
	3	Few tryp.
	4	
	5	
	6	Few tryp.
	7	
	8	
	9	
	10	
	11	
	12	
	13	
	14	
	15	Weak, watery eyes.
	16	
	17	Few tryp.
	18	Few tryp.
	19	
	20	
	21	
	22	
	23	Marked catarrhal conjunctivitis.
	24	
	25	
	26	Dead.

FIG. 155.—Temperature record of surra in a cat.

Blood infected with *Tr. lewisii* and kept on ice does not give an increased incubation period or produce any alteration of the infection, as long as motile parasites are found to be present. If, however, the blood is allowed to remain for a considerable length of time (forty-seven days), the incubation period is increased from six to nine days, and the infection is less severe. After fifty-one days or more on ice the blood no longer contains living parasites, but is still infectious for rats, with an incubation period of twenty-seven days. All writers agree that rats infected with *Tr. lewisii* show no symptoms of illness. The constant anatomic lesion is hypertrophy of the spleen.

Our work as a whole has been in conformity with that of others. In the thousands of rats found to be naturally infected with *Tr. lewisii* and in those inoculated, we have never observed either apparent illness or death which could positively be attributed to infection with this parasite, although it was present in enormous numbers in the circulating blood. Our observations have been exceptionally easy on account of the great number of rats furnished the laboratory for examination to determine the possibility of their infection with plague, since this disease has become endemic in Manila.

Very little is found in literature relating to the clinical manifestations and morbid anatomy of surra in rats. We have not seen a specific reference to the natural infection of these animals by *Tr. evansii*, though from our experience, which is to be described later, it is believed that Lingard must in some of his experiments have been working with such an infection.

Lingard states that the latent period in *Mus decumanus*, as developed by the subcutaneous inoculation of 0.1 to 0.2 c. c. of virulent blood, varies from one to two days; and in *Nesokia providens*, by subcutaneous inoculation of 0.2 c. c., from two to five days.

Kanthuck, Durham, and Blandford state that rats, when inoculated with nagana-infected blood, often exhibit convulsive seizures just before death, but otherwise show no symptoms of the disease, except dullness in the later stages. Transmission from one animal to another by coition, by suckling, or by any other method than by direct inoculation was not observed. Infected mice lived from eight to twenty-five days and rats from six to twenty-six days.

As the morbid anatomy of nagana in rats and mice, they describe lymphatic hyperplasia, most noticeable near the point of inoculation, congestion, œdema, and occasionally hemorrhages of the glands, great enlargement of the spleen, which is generally firm, friable, and dark in color, enlargement and fattiness of the liver, and occasionally a small amount of fluid in the pleural cavity.

Laveran and Mesnil state that in rats and mice of all varieties, including white ones, nagana has a perfectly regular course. No symptoms are manifest, the animal appearing well until near death. Mice appear sleepy and die without suffering from dyspnœa. One mouse had convulsions two hours before death. Some rats die with the same symptoms as mice, but most of them show great agitation just before death, crying out and dying in severe convulsions. There are no sensible variations of temperature in these animals. Parasites appear in the blood twenty-four hours or more after inoculation in the abdominal cavity, and on the second or third day after subcutaneous inoculation. They progressively increase in number until death. In white rats and mice death occurs in two and one-half to three days after intraperitoneal inoculations, and after three and one-half to five days following subcutaneous inoculations. Wharf rats (*Mus decumanus*) die in about the same length of time as white rats (*Mus rattus*).

According to Rouget, mice inoculated with *Trypanosoma* of dourine show no symptoms until near death, when the hair becomes rough and the cornea cloudy. The post-mortem changes observed are hyperemia of the abdominal layers, inflammation of the liver and spleen and of the lymphatics near the point of inoculation. Parasites are found in all of the organs and fluids except the intestines and the urine.

Voges says that death may occur without any preceeding signs of illness. In rats and mice inoculated with the *Trypanosoma* of mal de cadras there may be a few hours of comatose condition. The duration of the disease in these animals is given at about four weeks.

As has been stated above, the natural infection of rats with the *Trypanosoma*, which cause the disease in domestic animals has not before been reported, except perhaps, by Lingard, who, if such was the case in his work, misinterpreted his results.

In a preliminary report on Trypanosomiasis in the Philippine Islands, published as Bulletin No. 3, of the bureau of government laboratories, 1903, Musgrave and Williamson reported that a certain number of rats in Manila were found to be infected with the *Trypanosoma* which in this country causes surra in horses. This discovery was brought about by accident, while the authors were attempting to immunize a monkey with a parasite supposed to be *Tr. lewisii*. As a result the animal contracted surra and died. At first, following Lingard, we thought this to be a pathogenic *Tr. lewisii*, or supposed accidental infection with *Tr. evansii* to have occurred; but more careful study and the repetition of the experiment with the greatest precautions has demonstrated that a small percentage of these rats harbor the parasite causing the disease in the horse. This *Trypanosoma* has the same morphologic characteristics and upon inoculation is infectious for the same animals, producing the same disease with the same incubation period, course, termination, and lesions.

Wild rats are very unsatisfactory material to work with, because so many die after being in captivity a short time. The duration of life is so uncertain that but little confidence can be placed in results, even when control animals are used. The ones which live for a week or more after caging are likely to survive for some time, and in order to obtain the best results these have been employed as far as possible in our experiments.

As has been shown in other countries during the study of the disease in these animals, the infection is not evidenced by any symptoms of moment until just before death, when convulsions often occur. Too much importance should not be attached to this symptom, for time and again we have seen our control animals die in the same manner. Wild rats suffer such great excitement during the taking of temperature that no conclusions can be based upon the results. We must therefore believe that rats and mice infected with surra show no constant symptoms of practical significance. Some of the rare manifestations are cloudiness of the fluid in the anterior chamber, falling out of the long hairs about the head, and in a few cases œdema and a tendency to paralysis of the hind quarters. The incubation period, as determined by the appearance of parasites in the peripheral circulation, varies from a few hours to five days or more, and the duration is from two to twelve days.

The post-mortem examination shows an enlarged spleen, which may be hard and friable, or more nearly approach acute splenic tumor, with the organ usually dark in color, and there is generally enlargement of the lymphatics, especially of the inguinal region, which may be hemorrhagic. The changes in the other organs are not significant, except in a small number of cases which show gelatinous infiltrations of the subcutaneous and subserous tissues.

These lesions, particularly the enlarged spleen, are found in rats dying from infection with *Tr. lewisii*, which is considered harmless. After discovering that a number of rats harbor *Tr. evansii* we suspected the ones which died supposedly from *Tr. lewisii* and showed enlarged spleen, etc., post-mortem to be in reality infected with *Tr. evansii*; but animal experiment absolutely disproved this theory.

The study of trypanosomiasis in rats has not been completed. It is certain that rats in Manila may be infected both with a *Trypanosoma* harmless by inoculation to other animals and with one pathogenic for them. These parasites correspond microscopically to the descriptions, respectively, of *Tr. lewisii* and of *Tr. evansii*. We are not fully convinced that *Tr. lewisii* is always harmless for rats, or that some of the rats in Manila do not even harbor a third species of parasite.

TRYPANOSOMIASIS OF FROGS, FISH, AND FOWLS.

Trypanosoma have been found in frogs obtained from points scattered over a large area of the world, but they are usually considered harmless in these animals. The infection, so far as we have been able to determine, is not artificially transferable from frog to frog or from frogs to other animals. As already mentioned, we have not been able to find *Trypanosoma* in the blood of frogs in this country, and these batrachians have not been proved to be susceptible by inoculation with any of the *Trypanosoma* we have studied.

A number of observers have found fish harboring *Trypanosoma*, but all agree that no symptoms are produced. The species reported as infected are trout, pike, redeyes, soles, and salt-water fish of the Mediterranean (species not given). The different species of these parasites have already been discussed.

Laveran and Mesnil, whose work is the most important in this line, found the infection of the redeye with *Trypanoplasma* to be very common, but proved the young rarely to be infected. In the sole, however, trypanosomiasis is uncommon, being found in only four cases out of a large number of fish examined. They did not observe any symptoms of disease in fish caused by *Trypanosoma* and were unable to transfer the infection by inoculation. Doflein, during a fatal epidemic in fish, found *Trypanosoma* in a number of the diseased ones, but he was not sure of any pathogenic action of the parasites.

We have examined a number of fresh and salt water species of fish in Manila, but have been unable to find *Trypanosoma* in any of them, nor have we been able to infect them with *Tr. lewisii* or *Tr. evansii.*

It has already been shown in the discussion of *Trypanosoma* that some birds are occasionally found to harbor a specific *Trypanosoma*, which, however, does not appear harmful to them. With reference to the inoculation of *Tr. evansii, Tr. brucei, Tr. rougetii*, and *Tr. elmassianii* into birds, the evidence is somewhat contradictory for the different species. Most writers agree that birds are not susceptible tc infection, but Voges, writing of mal de caderas, considers turkeys, ducks, and chickens suceptible by inoculation. He says that chickens die in from two to three weeks, in great agony, from either subcutaneous or intraperitoneal injections. The only symptom noticed is emaciation, and parasites are very few in number in the circulation.

We have so far experimented with several varieties of birds, including maya, pigeons, doves, and chickens, but have been unable to infect them. No symptoms are produced, parasites are not found, and the blood proves noninfectious when inoculated into susceptible animals.

TRYPANOSOMIASIS OF MAN.

In 1898 Nepveu published an account of the occurrence of *Trypanosoma* in human beings. An extract from his article, translated, reads as follows:

"So far *Trypanosoma* have been found only in the blood of animals. In India they have been found in the blood of the rat (Lewis), the horse (surra epidemics), the dog, and the domesticated elephant. In Africa they have been discovered in the disease caused by the tsetse fly, and in Europe in the blood of the rat, the rabbit, various birds, and the frog. No one seems to have as yet observed them in man, although Laveran states that Barron found certain flagellated protozoa of an undetermined genus in the blood of an anæmic woman. In 1890, while making researches on malarial parasites in Algiers, I found flagellates in the blood of a patient, besides *Laverania*, and I was able to count three to each preparation of 18 square millimeters. At about that time (see Nepveu, Etudes sur les Parasites du Sang chez les Paludiques, 21, 1891, in Bulletin et Memoires de la Société de Biologie) I published some of the drawings I had so far collected. I hoped then that I might be able to complete my first observations by a more detailed study, but since then I have rarely been able to find the parasites. I have, therefore, decided to publish the following facts, in the hope of drawing the attention of such naturalists and physicians as will have the opportunity of completing these researches. * * *

"In over 200 patients, mostly malarial, of whom I have examined the blood, I have found these various forms of *Trypanosoma* in only six, three of whom were suffering from quotidian fever (Khill, Langevelle, and Bichielli), one from double tertian (Hendrick), and two from pernicious comatose fever (Cabane and Ginestet), while the seventh observation was made on Doctor X, who was apparently in good health. In none of these patients have I been able to observe any symptoms characteristic of this special parasitic invasion. They were almost all suffering from the effects of *Laverania*, which prevailed everywhere in its various forms. This seems, therefore, purely a coincidence, which has appeared to me worthy of notice."

His article attracted very little attention, some writers mentioning his work with the remark that his descriptions were inaccurate, and many overlooking it entirely. He did not attach clinical importance to the appearance of these parasites in the blood, but his remarks regarding them seem to us perfectly clear as to the occurrence of *Trypanosoma* in the blood, sufficiently so as to entitle him to credit for priority in the discovery of *Trypanosoma* in the human blood. His description does not appear sufficiently ample to designate the species of his parasite; but when one considers the confusion which exists even at the present time regarding the classification of these organisms, Nepveu can not be denied the credit because in 1898 he failed to classify his *Trypanosoma*. The parasites more recently discovered in human blood, as in his case, have not been clearly classified. Nepveu observed seven cases.

The eighth case of trypanosomiasis in man is published in the British Medical Journal for January 1, 1902, in an editorial and telegram from Dutton, in which he announces the discovery of *Trypanosoma* in a European, who displayed peculiar symptoms. The same journal for January 11, 1902, contains a letter from Ross, in which he gives Dutton credit for the following clinical data:

"The patient has been suffering from a form of relapsing fever with peculiar œdema of the eyelids and puffiness of the face, also œdema of the legs, general weakness, abnormal frequency of pulse and respiration, and enlarged spleen. There was no organic lesion of the heart and kidneys, and no malarial parasites were found after repeated examinations. The relapsing fever recalls that of horses suffering from the same parasite. It is not yet certain whether the parasite approximates *Tr. brucei* or *Tr. lewisii.*"

Dutton considers the most valuable features presented by his case as (1) its chronic course, (2) the general wasting and weakness, (3) the irregular rise of temperature, which is never very high and of a relapsing type, (4) the local œdemas, (5) the congested areas of the skin, (6) the enlargement of the spleen, and (7) the constant increased frequency of pulse and respiration (hurried breathing).

He examined the blood of 150 healthy children between the ages of 1 and 15 years, natives of Gambia, and says that he found *Trypanosoma* apparently identical with those observed in the European—the ninth case. This child is reported as showing no clinical evidence of the disease.

Forde (Journal Tropical Medicine, September 1, 1902) publishes the case already described by Dutton. He deals particularly with its history and symptoms previous to Dutton's personal observations.

The patient was a European, 42 years old, and at the time he came under Doctor Forde's care, May 10, 1901, at the Colonial Hospital, Bathurst, was a man of robust constitution, living a regular and steady life.

He was at first thought to be suffering from malarial fever, but quinine produced very little change in the course of the temperature. His blood was examined and malarial parasites were not found, but in nearly every specimen Forde found "small worm-like bodies," which he at first considered a species of *Filaria.* After repeated observations, however, the diagnosis became doubtful, and he associated these bodies with the symptoms of the disease.

The patient was invalided to Europe and returned to Bathurst in December, 1901. At this time Doctor Dutton, being informed of the case and examining the patient's blood, again found parasites, and immediately recognized them as *Trypanosoma.*

Forde gives as the chief characteristics of this case: (1) The irregular, intermittent temperature; (2) the œdematous condition of the face and lower extremities; (3) the rapid and variable pulse and respiration, unaccompanied by any evident cause; (4) the loss of weight, with marked debility, wasting, and lassitude; (5) the persistence of these symptoms and their resistance to treatment.

In the Journal of Tropical Medicine for November 1, 1902, is published "A case of trypanosomiasis in a European," under the care of Doctor Manson—the tenth case. Manson had been struck by the peculiar clinical features of Forde's case, its chronic, irregular fever, the enlargement of the spleen, the œdema, especially of the face, and the very well marked erythema multiforma scattered over the trunk and limbs.

The patient under Manson's observation was the wife of a missionary, who had resided on the upper Kongo for about a year, and had been sent to Manson by Habershon. She had been suffering while on the Kongo from an irregular fever, which was still present when she came under observation, though she had been living in England for the past eight months, and had been drugged with quinine and arsenic.

On examining her Manson recognized the same grouping of symptoms he had seen in Forde's case. The patient was admitted to the hospital and her blood was examined daily for two weeks, but no *Trypanosoma* were found. While arrangements were being made to test the tentative diagnosis by injecting blood into animals, Doctor Daniels, while making a blood count, found a *Trypanosoma,* and on subsequent examinations more parasites were observed. In the British Medical Journal, May 30, 1903, this case is accurately described by Manson and Daniels.

Manson publishes the eleventh case of trypanosomiasis in human beings. The patient was a European lady who had resided on the Kongo. In this case an erythematous rash was a prominent symptom, preceding or accompanying the attacks of fever, which occurred every ten days and lasted each time for about three. The cause of the disease is attributed to the bite of some insect on the foot. Manson is inclined to attribute significance to a tick (*Argas moubata*) as a transmitter of the infection. Baker has recently reported three more cases in human beings in Uganda.

Broeden, according to a letter received by Doctor Manson, has discovered two more cases in human beings—the twelfth and thirteenth. Both of these were Europeans.

Of the sixteen cases of trypanosomiasis in man, two have been in apparently healthy persons, six associated with malarial fever, and eight have shown clinical symptoms apparently entirely due to the infection with *Trypanosoma.* In these five cases the clinical picture, which has already been reviewed, was peculiar and quite similar.

Castellani has reported the discovery of a *Trypanosoma* in the cerebro-spinal fluid of 20 out of 34 cases of sleeping sickness. He has described the parasite and proposed the name *Tr. ugandense.* Bruce has continued Castellani's work, and has reported to the Royal Society the discovery of *Trypanosoma* in the fluid obtained by lumbar punctures in all of the 38 cases examined, and in 12 out of 13 of these cases he found the *Trypanosoma* also in the blood. The importance of this discovery can hardly be estimated at the present time, but it is certainly additional evidence of the increasing importance of this subject. Lieshman has also recently reported the possible appearance of *Trypanosoma* in the blood of patients suffering with "dumdum" fever in India.

Since the beginning of the present work in Manila constant vigilance has been observed in order to discover the infection in man, but so far with negative results. Neither the clinical symptoms nor the parasites have been found. The blood of hundreds of cases of persons ill and in health has been examined, particularly that of persons who have come in close and frequent contact with animals suffering from the disease. Both writers of this article have repeatedly performed post-mortem examinations on animals which had been but a few minutes dead of the disease, and have been bitten by flies covering the infected organs, but without the slightest inconvenience. A number of assistants during the course of the work have often exposed open skin wounds to infection, both by blood directly and by biting flies, but all with negative results.

The reported cases show conclusively that human beings may become infected, and we shall continue our observations in this country, where the constant presence of the disease in animals, the sanitary conditions, and the anæmic state of most of the inhabitants would lead us to expect a case eventually to occur in a human being.

TRYPANOSOMA OF MISCELLANEOUS ANIMALS.

Here we shall briefly mention the notes found in literature relating to such animals as have contracted the disease, but in the case of which the clinical manifestations have been given but little detailed discussion and on which, owing to the lack of animals, no observations can be made by us.

Bruce proved by animal experiment 9 out of 35 wild animals examined in South Africa to be infected with *Tr. brucei*. The positive ones included 1 buffalo, 3 *niedbeuste*, 3 koodoo (*Strepsiceros kudu*), 1 buch-buck, and 1 hyena. Many of these animals showed no clinical evidence of disease.

Laveran and Mesnil, in mentioning the animals susceptible to nagana, give several species of antelopes, the dromedary, the hare, the mulet, the hyena, the lapian, the hedgehog, the macque. Bruce mentions the babale and Brumpt the chamois. Lingard and others say that buffaloes and elephants are susceptible. Sivori and Lecler refer to the carpincho and Voges to the nutria (*Myopotamus coypus*) among animals subject to the infection.

Voges considers the nutria extremely susceptible. Death occurs suddenly about ten days after inoculation, without symptoms.

Laveran and Mesnil say that wolves have an incubation period of two to three days and that death takes place in from five to twelve after inoculation. Parasites vary in number, but are usually to be found throughout the disease by microscopic examination of the blood. Cachexia and irregular fever are the prominent symptoms.

In strong, healthy animals the course of the disease is much longer, being twelve to fourteen days or more, and the period of incubation is from four to five days. The blood is always infectious, but parasites are not usually found in it by microscopic examination. Local symptoms appear in twenty to thirty days. Emaciation is not noticed until just before death.

The prominent symptoms, when once established, are conjunctivitis, coryza, œdema, particularly of the head, the legs, and the genitals; congestion of the testicles, or even a true architis; falling out of the hair about the eyes, nose, and base of the ears; opacity of the cornea; sometimes purulent conjunctivitis and blindness in the late stages; ulcers around the eyes, nose, and other parts of the body similar to those seen in dourine. In animals dying from twenty to thirty days after inoculation the marked clinical symptoms are not observed. English writers give the incubation period at eight days and the duration of the disease at twelve to fifty-eight (average, thirty days).

Several writers mention hamsters as susceptible.

Hagger states that surra runs a very chronic course in camels, and that the natives believe that a small portion of those surviving for three years recover. He gives as the principal symptoms fever, swelling on the right side of the chest, in the scrotum and sheath of males and in the udder of females, frequent abscess formations in these regions; progressive anæmia and rapid emaciation. The appetite remains good. Parasites are present in the blood during fever, and are absent during intermissions.

The several forms of the disease are said to run a chronic course, somewhat similar to that of the goat, in the deer.

COURSE, DURATION, AND PROGNOSIS.

The course of the disease varies in the same, and considerably more so in different species of animals. In the language of Laveran and Mesnil, "it always shows the general characteristics of blood infection."

A temperature of remittent, intermittent, or relapsing type is present in nearly all animals, including man. Progressive anæmia and emaciation are also constant manifestations. It is rarely a very acute infection, although in exceptional cases it becomes so intense as to suggest septicæmia.

The duration is also variable, both in like and unlike animals. Schilling says that the surra of South Africa lasts from thirty-six days to eight months in horses. He considers the acuteness of the disease to be influenced somewhat by the number of parasites in the blood. Bruce says that horses live for weeks and months with nagana.

In the Philippine Islands the duration of the disease in horses does not show a greater variation than it does in other countries. It is from fourteen days to three months, and is about the same for American, Australian, Chinese, and native horses.

The length of time the disease lasts in cattle is usually somewhat longer. Bruce had a cow sick with nagana under observation during eighteen months.

The prognosis is influenced to a certain extent by the species of the animal infected. Most writers agree that it is invariably fatal in horses, but there are some exceptions. Schilling believes that some horses recover; and Laveran and Mesnil say that recoveries have been reported in South America, although they have seen none. A varying percentage of cattle, according to careful observers, recover. Bruce says that cattle occasionally recover from nagana, and Laveran and Mesnil have had similar results. Lingard believes that a large proportion of cattle recover. Voges, on the other hand, considers the cattle of South America immune.

The annual report of the division of the chief quartermaster of the Philippine Islands for the year ending June 30, 1902, records the death of 3,693 horses and mules out of a total of 17,220 on hand. He adds that most of this havoc was produced by surra and glanders.

The course, duration, and prognosis of the disease have been considered somewhat in detail under the discussion of the different species of animals.

The duration, in particular, varies so much with environment, the constitution of the animal, and probably with other conditions which we do not understand, that it can not be fixed except within wide limits. The prognosis is always grave, the mortality in most species of animals being 100 per cent. The only exception to this fact among domestic animals of economic importance is found in cattle, a varying percentage of which recover.

COMPLICATIONS.

Broncho-pneumonia, observed especially in horses, has been mentioned by writers as a frequent complication. In this country œdema and congestion of the lungs is common, while broncho-pneumonia, more or less extensive in character, is occasionally seen.

Nephritis, hydropericardium, and hydrothorax sometimes explain unusual symptoms. Tuberculosis and surra are not infrequently associated, especially in monkeys. We have had two cases of surra and glanders in the same animals. Filariasis and surra often occur together in dogs. Rinderpest sometimes develops in cattle suffering with surra.

Other diseases which we have found associated with surra are foot-and-mouth disease, psuedo-actinomycosis, pseudo-farcy, malignant neoplasms, and at least two septicæmic conditions not fully understood.

DIAGNOSIS.

In order to carry into effect methods looking to prevention, an early diagnosis is very desirable in all cases. Fortunately in the horse, the most frequently infected of all animals, this is in the majority of cases easily done by a microscopic examination of the blood, which consists in examining a specimen prepared in the same manner as one to be examined for malarial parasites. The *Trypanosoma* are readily observed with a Zeiss DD or AA and ocular 4, and are usually in sufficient numbers to be quickly seen. In many cases, however, they may be so few as to require considerable time and the examination of several specimens before they are found; and, as has already been said, they may not be observed at all for several days at a time by this method.

When infection is suspected and parasites are not found in the blood there are two courses open: First, microscopic examination, carried on for several days if necessary, will usually suffice for making the diagnosis in horses and in several other animals in which the parasites are but rarely absent for more than a few days at a time in the early stages of the disease. The second course is to test the blood by animal experiment. For this determination any of the smaller animals, particularly dogs, monkeys, and white rats and mice, are satisfactory. A few drops to 1 c. c. of blood from the suspected animal may be injected under the skin, or preferably into the abdominal cavity, on account of the shorter incubation period, after which the parasites may be demonstrated in the usual way.

The objection to the latter method is the expense of the animal and the length of time necessary for the appearance of the parasites. On the other hand, results are certain, and in the case of some animals time is saved. This method, however, is absolutely necessary in many cases of infection in cattle, goats, sheep, and some other animals, and should be employed in all cases of doubt from any cause.

Whatever the method used, a determination of the blood infection is absolutely the only way to make an early positive diagnosis of the disease in any species of animal, and it is well constantly to bear this in mind in performing work which means so much in suppressing an epidemic.

As has already been said, the early clinical manifestations are slight. The temperature, always highest in the afternoon, is constant in most animals immediately after the incubation period, but may drop to normal again very quickly and remain so for days. When present during an epidemic it is significant, but its frequent absence leaves much to be desired. The next symptoms to appear are catarrhal discharges from the nose and eyes and a beginning pallor of the mucous membrane. Even with all these symptoms, which may not be fully developed for a week, the diagnosis is still not absolutely certain without a determination of parasites in the blood.

With the development of other symptoms, such as œdema and incoordinations, in addition to those already mentioned, a diagnosis upon appearance alone is justifiable.

DIFFERENTIAL DIAGNOSIS OF SURRA, NAGANA, DOURINE, AND MAL DE CADERAS

Very little convincing work has been done to solve this important question, for the reason that very few workers have had the opportunity of studying more than one of the affections. In most cases authors have contented themselves with the conclusion that, if not identical, they are closely allied. Koch, who worked particularly with surra and nagana, considered the parasites and the resulting infections identical, and many others have formed similar conclusions, while Voges, Laveran and Mesnil, and others maintain certain differences to exist.

Writing of nagana and mal de caderas, Laveran and Mesnil consider them distinct morbid entities, which can not be separated by their clinical symptoms, and they further maintain that species of animals which are susceptible to one can also be infected by the other. They classify their reasons for considering the two diseases to be distinct under three headings: (1) Constant morphologic differences between *Tr. brucei* and *Tr. equinum;* (2) animals immunized against nagana do not have for *Tr. equinum* the same activity that they possess for *Tr. brucei,* and (3) animals immunized against nagana are susceptible to mal de caderas.

The morphologic differences between the two *Trypanosoma* have already been considered, and regarding the other points of difference Laveran and Mesnil explain themselves in substance as follows:

A deer recovered from nagana at the end of eight months, and, having received during the interval fifteen inoculations of 10 to 60 c. c. of the blood of a dog affected with nagana without contracting the infection again, was inoculated in the skin with 1 c. c. of diluted blood of a rat suffering with mal de caderas. Blood taken from the deer five days after this inoculation was infectious for mice by intraperitoneal injection.

A sheep cured from nagana after a period of one month, and which had received during this time inoculations of 10 c. c. to 20 c. c. of blood from a dog suffering with nagana, was inoculated subcutaneously with 0.5 c. c. of diluted blood from a mouse sick with mal de caderas. The blood of this sheep obtained five days after the last inoculation and injected into the peritoneum of a rat (with a dose of 3 c. c.) and of two mice (with doses of 0.25 c. c.) gave to them an infection caused by the *Trypanosoma* of mal de caderas, with an incubation period of less than four days.

Blood taken again after fifteen days from mal de caderas and injected into the peritoneum of a rat and a mouse conveyed the disease with an incubation period of four to six days. The blood of a control sheep, which had not yet received an injection of *Trypanosoma* of nagana, examined on the fifth and thirteenth days after inoculation of mal de caderas, showed the same virulence as the blood of sheep recovered from nagana and infected with mal de caderas.

The question as to whether the serum of animals immunized against nagana is active for *Tr. brucei* and without action for *Tr. equinum* is discussed by Laveran and Mesnil as follows:

"I. The serum of a deer immunized against nagana, when given in a dose of 1 c. c. containing from $\frac{1}{5}$ to $\frac{1}{20}$ c. c. of blood of mal de caderas, showed no action on the incubation period or on the progress of the infection in mice inoculated with the mixture. The same quantity of this serum, mixed with corresponding doses of blood of nagana, prolonged the incubation period of the disease about five days.

"II. The serum of a sheep which had recovered from nagana, when given in a dose of 1 c. c., or even 2 c. c., mixed with doses varying from $\frac{1}{10}$ to $\frac{1}{20}$ c. c. of diluted blood of a dog having mal de caderas, had no action on the incubation period or on the progress of the infection in mice inoculated with the mixture. The same serum, in a dose of 0.5 c. c. mixed with $\frac{1}{10}$ c. c. of diluted blood of a dog, prevented all infection in the rats inoculated with this mixture. We also experimented with a mixture of 1 c. c. of the serum with 0.5 c. c. of the same diluted blood."

Bruce considers nagana and surra analogous, if not homologous, diseases. Weber and Nocard have concluded that surra, nagana, and dourine are the same disease, with slightly different symptoms. Schilling considers them all closely related or identical. Curry believes surra and nagana probably to be the same, but does not know with which to place the Philippine epidemic.

Salmon and Stiles state that the majority of writers consider surra and nagana the same disease, but that they maintain dourine to be different. Sivori and Lecler from their studies think that the parasites of surra and nagana are identical.

Voges will not venture a decision as to whether mal de caderas and dourine are the same disease. He points out in detail their great similarity. He considers these diseases different from surra for the following reasons:

(1) "Dourine and mal de caderas can not be transmitted to cattle, which animals are directly attacked by surra." (2) "In regions where mal de caderas exists cattle do not die from surra." (3) "We have no reason to believe that *Trypanosoma* show the same irregularities of virulence as bacteria, so that the different forms of the disease may be said to be produced by different degrees of virulence in the same *Trypanosoma*. On the contrary, during our four years of experimentation, the latter have shown a constant virulence." The fourth reason, which he considers decisive, is based upon the morphologic differences in the parasites, which have already been discussed. In conclusion he says, "I think these four proofs are entirely sufficient to establish for all time the difference between surra and dourine, as well as between surra and mal de caderas."

In another article Laveran and Mesnil give extensive consideration to the differences between surra and nagana, which in substance is as follows:

"The same animals are susceptible to both of them—the horse, the ass (except perhaps certain races), the mule, the goat (in the Dutch East Indies they are refractory to surra), the sheep, the cow, the camel, the dog, the cat, the monkey (long-tailed macayo), the rabbit, the guinea pig, and the rat. In the horse, the course of the disease is the same, whether surra or nagana. The animal dies at the end of the same time (thirty days on the average). In the case of experimental inoculation, the incubation period is the same, there are the same lesions of the eye and lids, the same œdema, the same degree of ænemia, the same emaciation, followed by final paresis preceding death. The fever is of the same type, except that it is perhaps more clearly intermittent in the case of surra; besides, during the intermissions, which may last from one to six days, the parasites are not seen in surra by microscopical examination, whereas they are very rarely absent in nagana. (Lingard insists particularly on this difference.) In short, the differences are minimum.

"The other equides—the goat, the sheep, and the dog—die of the two diseases in the same length of time and with practically the same symptoms. * * * Rabbits, guinea pigs, and rats (*Mus decumanus*) succumb to surra with about the same symptoms as nagana.

"Cows remain to be considered. Few survive nagana (according to Bruce, Koch, and African explorers in general). On the contrary, they generally recover from surra. According to Lingard, death from this disease is in fact exceptional. The animal becomes considerably emaciated, but recovers its health, and a second inoculation does no harm. This appears to be a sharply marked difference between the two diseases. Perhaps this is owing to a difference of race, as Rogers has supposed, recalling the experience of Koch relating to the asses of Massai. In any case, the question should be settled by experimental methods. If the supposition of Rogers is considered incorrect, the question may be determined by proving whether cows inoculated with several doses of surra blood are susceptible to nagana. Not until these experiments have been made can a positive conclusion be given."

Mal de caderas.—Passing next to mal de caderas, Laveran and Mesnil believe that in most of its principal symptoms "it does not differ at all from surra and nagana, but hematuria is frequently present. Paralysis of the posterior extremities, * * * a marked symptom of the South American disease, * * * is undoubtedly more pronounced than in surra or nagana.

"The dog, the sheep, the goat, the cat, the monkey, the rabbit, the guinea pig, the rat, and the mouse succumbed at the end of various periods, according to the species of the animal (five to twelve days for the rat; four to eight days for the mouse; ten to fifteen days for the monkey, and three months or more for the goat and the sheep). In the rabbit the course is slow, and the animal presents the same symptoms of the eyes and genital organs as we have noted in nagana.

"Cows are absolutely refractory. Argentine scientists mention a bull which was inoculated every eight days for a year and a half with 200 to 300 c. c. of blood from a sick horse without showing any signs of the disease. They do not say whether an examination of the blood was made or a susceptible animal inoculated with it, especially during the month which followed the first injection."

In short, Laveran and Mesnil consider mal de caderas very closely related to surra and nagana.

Continuing this discussion with reference to dourine, Laveran and Mesnil say:

"We have already shown * * * that the *Trypanosoma* of dourine present morphological differences from that of nagana. This is an important argument in favor of the nonidentity of the two diseases. The etiology is completely different. Contagion by coition seems to be the only natural mode of infection for dourine, as no spontaneous cases are known in geldings and mules. Insects, then, play no part in the propagation of dourine.

"May nagana be contracted by coition? It is not probable, as no contagion results from depositing the virus on an unbroken mucous membrane. Nevertheless the experiment should be made, especially in the case of the rabbit.

"The first symptoms (in the horse) appear ten to twenty days after the infecting coition. * * * In the male there is edematous enlargement of the foreskin, then of the extremity of the penis, and a slight muco-purulent oozing from the urethral mucous membrane, which is inflamed. In the female there is an enlargement of the two lips, or of one alone, with a muco-purulent discharge from the inflamed vaginal mucous membranes.

"When this has persisted for a short time, other phenomena are manifested, as edema of the limbs and abdominal regions, progressive anemia, constant emaciation in spite of good appetite, weakness of the muscles, especially of the posterior extremities, and often sharp flexions of the joints. Certain symptoms are pathognomonic, so to speak, as the cutaneous patches seen on various parts of the body. There is hardly any fever; the temperature rarely passes 30° C.

"The disease generally lasts from four to ten months, and has never the acute character of nagana or surra.

"Toward the end of life ocular troubles (conjunctivitis, ulcerative keratitis) are sometimes noticed; the pareses are accentuated; there may be pronounced or very nearly complete paraplegia; and at autopsy foci of softening of the medulla may be observed, which is never the case in nagana or surra. * * *

"The common symptoms of dourine and nagana then are striking. As to the special symptoms of dourine (cutaneous plaques, foci of softening of the medulla), they are not constant (the cutaneous plaques, for example, generally being absent in the ass) and may be considered in accord with the slower course of the disease. Nocard 'has been able to kill horses in four, six, and eight weeks with a temperature curve identical to that which characterizes surra and nagana.'"

Considering dourine in their animals, they say:

"The dog, the rabbit, the rat, and the mouse are susceptible, but with exceptions and degrees of illness that show variations in the virulence of the infecting agent. * * * Rouget killed white mice in five to ten days with a general infection like nagana in its course. Only a small number of sewer rats succumbed, others recovered after having a sanguinary infection, while some were absolutely refractory. In the beginning of their studies, Buffard and Schneider had the same experience as Rouget on rats and mice, but Nocard, who after passage of their *Trypanosoma* through a dog, found rats and mice almost absolutely refractory, and it was only with the greatest difficulty that the virulence was sufficiently increased to make rats sensitive. In the rabbit and the dog the course of the disease is much the same as in the horse, and contagion may take place by coition.

"We wish to call particular attention to the lesions in the infected rabbit, already well described by the authors we have cited. They are much like those of rabbits infected with nagana. * * * With nagana, however, they never live longer than two months after inoculation, while in the case of dourine they may survive for more than six months with characteristic lesions. Experimental methods, therefore, do not show a sharp difference between dourine and nagana. * * * Cows are scarcely susceptible to surra and absolutely refractory to mal de caderas, the two diseases which we have shown to be so closely related to nagana.

"Finally, a recent experiment of Nocard shows that there is a difference between dourine and nagana, * * * which corroborates our morphological observations. A number of dogs highly immunized against dourine were inoculated with a very small quantity of blood taken from one of our mice and rich in *Trypanosoma* of nagana at the same time as a control. The two immunized dogs died of nagana in eleven days, the control in fourteen days."

The statement of Weber and Nocard and others that dourine is found naturally only in horses and donkeys has been used as an argument for the individuality of this disease. In looking over the work of these writers, however, it will be noticed, as has been pointed out by others, that their statements are based upon observations made in localities free from other forms of the disease, and in at least one case in a country free from the known insects of transmission. When dourine is transferred to a country where surra is prevalent, it has recently been shown that transmission takes place just as it does in this disease, so that it appears that Schilling's remark that coition is the natural mode of transmission only in the absence of the usual insects and other necessary environments, is rational, and goes a long way toward refuting one of the arguments for the individuality of this disease.

We have studied surra with special reference to the particular points brought out by writers in various other countries, and have been unable to find any clinical evidence that it is materially different from the description of any one of the other diseases, or that they differ sufficiently from each other to justify the continuation of so many names.

A comparative study of the *Trypanosoma* has already been discussed in a chapter devoted to that subject, and it is unnecessary to repeat conclusions here.

In summing up the whole matter it appears to us, when we take into consideration the work done by others and add our own results, that we are justified in believing surra, nagana, mal de caderas, and probably dourine, the same disease, and that all are caused by *Tr. evansii.*

We recently received from Java a cow suffering with surra when it arrived. Rinderpest also developed in this animal shortly after landing, and the surra not yet having been discovered, the blood of this animal was used by Doctor Jobling, director of the serum laboratory, in the immunization of three other cattle, two of which promptly developed trypanosomiasis. We have studied the parasites in these animals and the course of the infection in different animals, and have satisfied ourselves that it is the same disease with which we are working in Manila. If the transfer of surra from Java to this country causes such a change in the nature of the infection in cattle, it is not at all surprising that similar ones may be brought about by transferring it in other countries.

Laveran and Mesnil found that the parasite of nagana is not so virulent for their cattle in France as it is usually reported to be for those of Africa.

The immunization of animals against one form of the disease with attempts to prove them susceptible to another has been undertaken by several authors, and most flattering results have been reported; but on going over the work it does not appear that the presence of the first disease was disapproved by animal experiment in some of the so-called immune animals before the second one was administered.

A discussion of the very interesting and important question of the identity or difference of these various diseases, to be of any great value, must take into consideration two factors, (1) the morphology of the parasites and (2) their pathogenesis in full.

It is the old story of parasitic infections over again, the zoologist paying particular attention to the first of these considerations without full investigation of the second, and the strictly medical man doing the opposite.

In this case both points deserve careful consideration, but as the value of conclusions in sanitation and therapeutics are enhanced more by what the parasite does than by what it is, we acknowledge the pathogenesis to be of the greater importance, and shall so apply it in our discussion.

A number, if not all, of these diseases show a special tendency to lesions of the genitals, and if, as asserted, dourine is transmitted only by coition, this fact would serve merely to emphasize a symptom shown as a tendency in the others, and therefore does not place the diseases so far apart as might appear at a glance. Competent observers have shown, however, that in this disease, as in all others of trypanosomatic origin, the infection may be transferred by inoculation and the typical disease reproduced in this manner.

The supposed natural transmission of dourine only through coition has been explained by a recent writer as probably owing to the absence of the usual transmitting insects in the regions affected. In any event, it does not appear to have been demonstrated that insects are not capable of transmitting the infection. The other described characteristic manifestations of the disease—the peculiar skin lesions—are found by a careful review of literature not to be confined entirely to dourine and not to be constant in this disease, especially when produced by inoculation. So far, unfortunately, but little work appears to have been done with a view to determining the probability of transmission of the other forms through coition and the study of the disease so produced.

In the early reports on surra by Evans and others it was stated that the disease was very fatal for cattle as well as for horses, but in late years most of the writers say that these animals are somewhat more resistant, and that some of them recover. So, too, with nagana; in certain parts of Africa the disease is reported to be very fatal for cattle, but in other sections of that country and in other countries a greater resistance has been shown, and, as with surra, a certain number recover. When we look over carefully the literature relating to these diseases in cattle, we fail to find the marked differences so strongly emphasized by some authors as being diagnostic points in differentiating the two diseases, and, indeed, there are as great variations reported for the action of either of these diseases in cattle as there are reported for any two of the diseases in them, so that we are justified in concluding that there is nothing in the course of the various forms of trypanosomiasis in the same or different animals to warrant considering them distinct pathologic entities; in fact, the contrary would appear reasonable.

Absolute proof of the identity or individuality of these infections, as they exist in various countries, can be obtained only by importing infected animals for each individual disease into one place and carrying on their study under like environment. Until this is done we are inclined, as before stated, to regard surra, nagana, mal de caderas, and probably dourine as the same disease. This is a very interesting question and one which should be settled; but as far as providing means to combat the infection is concerned, a solution of this problem would not be likely to add anything of value. Means which prove efficacious for one form of the disease will probably do so for all.

SUSCEPTIBILITY AND NATURAL IMMUNITY.

A full discussion of this subject would involve a great deal of repetition, but owing to its importance in dealing with epidemics it will be briefly reviewed.

On the whole there is a most remarkable similarity in the degrees of susceptibility and immunity of various animals to surra, nagana and mal de caderas. There are individual differences; but it must be remembered that many factors contribute to such differences, since experimentation is carried on in various parts of the world.

Schilling mentions pigs as the only animals refractory to African surra; others, however, have shown that they may contract this disease, and they are considered to be susceptible to the other forms of trypanosomiasis as well. Penning says that the cattle of Java do not contract surra, while Schat considers them susceptible. The chronic course of surra and nagana in cattle and the reported natural immunity of these animals to mal de caderas are not sufficiently at variance to justify the statement that the difference is diagnostic.*

Lingard considers buffaloes susceptible, but says they may recover from the infection. These results do not differ from those reported in relation to the same animals in other countries. He also cites the case of a horse which he cured of surra with arsenic, iodide of arsenic and mercury, but twelve months after the cure the animal died of the disease from the inoculation of one drop of virulent blood.

Sivori and Lecler were unable to find *Trypanosoma* in carpinchos, tapirs, peccaries, stags, small deer, pumas, tigers, and the *Lutra brasiliens*.

Birds, according to Foa, are absolutely refractory to large doses injected subcutaneously, abdominally, or through the eye. Voges, on the other hand, claims that chickens, ducks, and turkeys are susceptible by inoculation to mal de caderas. Later reports state that the birds of South America are immune.

Voges believes that the cow is the only animal naturally immune to mal de caderas. He proved horses, mules, donkeys, sheep, goats, rabbits, dogs, guinea pigs, white and gray rats, and white and gray mice to be susceptible.

Rouget determined birds, bats, and guinea pigs to be resistent to *Tr. equiperdum*. Sewer rats also showed a partial immunity. Kanthuck, Durham, and Blandford consider the sheep and deer of Africa resistent to nagana; and Koch says that the asses of Massai and the crosses of these asses with those of Mosket are immune to the same disease.

Salmon and Stiles mention horses, asses, mules, camels, elephants, cats, dogs, cattle, buffaloes, sheep, goats, rabbits, guinea pigs, rats (*Mus decumanus* and *Nesokia providens*), and monkeys as susceptible to surra. They say that birds, reptiles, amphibia, and fish are immune to the *Trypanosoma* of mammals. The gaur (Indian bison) and the tsaing, according to Evans, have never been observed to have surra.

Ducks, roosters, doves, sucking pigs, and kids (a short-legged variety of goat found in Toga) were inoculated by Ziemann, and recovered permanently from the disease.

Curry considers chickens immune by inoculation. He found horses, cows, carabaos, monkeys, dogs, cats, and rats susceptible to infection with *Tr.evansii* of the Philippines.

The only animals naturally susceptible to *Tr. lewisii* are wild and gray rats and mice; white rats and mice, and tachetes may acquire the disease by inoculation. Laveran and Mesnil, and others have shown that guinea pigs inoculated in the abdominal cavity are temporarily infected in a certain percentage of cases. To these may be added monkeys and puppies.

Rouget showed that white and gray rats and mice, rabbits, and dogs inoculated subcutaneously, intraperitoneally, in the abdominal cavity, or by dropping infected blood into the conjunctiva, are susceptible to *Tr. equiperdum.* Wasielewski and Senn found *Tr. equiperdum* in horses and asses, and successfully inoculated horses and dogs with it.

Voges mentions dogs, horses, rabbits, rats, mice, and guinea pigs as susceptible by inoculation to dourine. Weber and Nocard say that this disease may be inoculated subcutaneously, abdominally, or in the scrotum or vagina in the case of the dog, the horse, the donkey, the rabbit, and the mouse.

Bruce proved the horse, mule, ass, cow, dog, cat, buffalo, hyena, bobale, and several other animals susceptible to nagana.

Laveran and Mesnil mention among the animals which may contract mal de caderas horses, asses, mules, cattle, sheep, goats, rabbits, guinea pigs, dogs, cats, rats, camels, elephants, and monkeys. Brumpt found the chamois susceptible.

There is no doubt that cattle have a relative natural immunity, which seems to vary somewhat in different countries, but this variation is not great enough to be of especial diagnostic significance.

The value of keeping in view the relative immunity of certain animals, in addition to its scientific interest, lies in its practical significance in providing measures for the suppression of an epidemic. The animals showing this tendency in the greatest degree are those which also give the least physical evidence of infection, and consequently are dangerous in that they provide hosts for its perpetuation. It is in these animals that parasites are often present only in small numbers in the peripheral circulation, necessitating animal experiment fully to establish a diagnosis.

PROPHYLAXIS.

The question of prophylaxis constitutes the next important part of this subject. All efforts to cure the disease having failed, and there being but slight prospect of working out methods which will be successful in the treatment of an animal once infected, our highest hope lies in being able to bring about a practical and at the same time efficient condition of prevention.

A curative treatment of animals suffering with this disease is not at all necessary to the welfare of the community which has the infection in its midst. It is a disease belonging to the class readily controlled by preventive measures, just as the case with many of the infectious diseases of man for which we have no cure. Practical rules for the control, and even for the suppression of an epidemic, may be prepared and enforced with no great difficulty; and the failure to do so shows a lack of progress in proportion to that evidenced in the control of the less important diseases.

With the aggregate of the findings on the nature and mode of transmission of this disease before us, and considering the practicable manner in which this knowledge may be applied efficiently to control the infection, one can not help wondering that the annual loss of millions of animals from this scourge is permitted.

With the possible exception of rinderpest, it is the most important disease of animals with which a large part of the tropical world is infected. From an economic standpoint, measures looking to its control are of greater importance to the public welfare than are many of the diseases of man on which annually are spent millions of dollars.

Quarantine regulations governing the importation of animals are obviously the first point to consider in the discussion of preventive measures. Very few countries have efficient quarantine laws. France prohibits the importation of animals from infected countries, and the United States does not allow animals to be imported from the Philippines. Recently a few other countries have been considering similar steps.

Laveran and Mesnil state that "the importation of animals from infected countries should be prohibited or greatly restricted. All animals arriving at a port should be examined and if any are found to be infected, these should be killed and the others isolated. If the disease gains entrance to a new country, preventive measures, if established early, should prove efficient."

In a preliminary report, Bulletin No. 3, bureau of government laboratories, Musgrave and Williamson in part say as follows:

"1. Prevention of reinfection of the country by proper quarantine laws.

"2. Eradication of the present infection by enforcing efficient sanitary regulations.

"It is believed that the methods to be described are practicable, and, if adopted, will prove sufficient to control the epidemic and eventually to eradicate it from the country; but to give the best results work should be begun at once, during the dry season, while the cases are comparatively rare and before the wet season comes with its great increase in the number of biting flies and the consequent spread of infection.

"Had vigorous methods been adopted when the disease first appeared in this country, in 1901, there would not have been an epidemic; and even now, were proper procedure followed persistently, the disease should be eradicated from the Islands. If, however, no more efficient course is adopted than the one in use now, the disease will go on spreading until the whole country is involved and the epidemic becomes perpetuated, as it has been in Africa, South America, India, and other countries.

"The subject is an all-important one to the country, and it is imperative that facts and suggestions as to remedies be placed before our legislators. Without legal authority, municipal sanitation (as history so well demonstrates) must always be a failure; but with the authority given by proper ordinances, a disease such as trypanosomiasis of horses should be controlled from the start and finally eradicated from any country in which it has obtained a foothold.

"In considering quarantine regulations against the introduction of trypanosomiasis into a noninfected country, a safe but hardly justifiable procedure would be to forbid the entrance of any animals from an infected port, as was so promptly done by the United States against the Philippine Islands when the disease was first reported here. Whether our home country enforces the same stringent laws against all others infected with trypanosomiasis and against all animals which have been in infected countries but are shipped to America from noninfected ports, can not, without full knowledge of the quarantine laws, be stated; but, granting this to be so, there still remain reasons for stating that there must be forces other than quarantine laws which prevent the introduction of trypanosomiasis into the United States. Wild animals for circuses and other purposes are certainly admitted in considerable numbers from infected countries, and when we consider the fact that many of these animals harbor the parasite without inconvenience, the introduction of the infecting agent into America at some time or other seems very probable. Not alone quarantine laws, but other factors, such as possibly conditions of temperature, moisture, and carrying agents, probably play a part in preventing the spread of the disease.

"However, trypanosomiasis has gained admission to the Philippine Islands, and, so far as we are concerned, there is no need of discussing the quarantine laws necessary to prevent infection in a virgin country. It would have been entirely feasible, as is shown by accumulated experience, to have prevented the introduction of the disease into the Philippine Islands, with its subsequent disastrous results, by the enforcement of proper quarantine regulations without actually prohibiting the importation of animals. That this was not done is owing to the fact that the disease was not recognized until after its introduction and to our inexperience in dealing with tropical conditions, but it would appear in place to sound a note of warning to other countries, especially those within the geographically infected zone and which are as yet without the disease. It is a question of economic importance second to none in a large area of the world, and deserves the closest attention and prompt action of the sanitary guardians of the public welfare."

In framing quarantine laws particular attention should be paid to wild animals and to circus animals in general.

It has already been shown in discussing the etiology and modes of transmission of the disease that every case of infection is entirely dependent upon exposure to biting insects, and that this brings us in the outset face to face with the necessity of (1) destroying all infected animals, (2) destroying biting insects, (3) employing a combination of these methods, or (4) rendering susceptible animals immune.

Before beginning a discussion of these points we shall review somewhat fully the recommendations of Voges, of South America, and Schat, of Java, who have written in detail upon this subject.

Voges considers preventive measures under two headings: General means and specific means. The burning of cadavers need no longer be recommended, since we know that twenty-four hours after death the tissues and fluids are no longer infectious. It is sufficient to protect the bodies from biting insects during twenty-four hours. When the disease breaks out in pastures, the animals should be transferred to high, dry, grounds, and those already infected should be killed. Animals should not be allowed to run at large, but should be kept in stalls; and especially valuable ones may be protected from biting flies by screens.

Voges compares mal de caderas to malaria in the manner of its spread, etc., and suggests preventive measures along the lines used for the latter. He states that there are two methods of preventing malaria—that of the Italian school, which bases its work upon the destruction of the intermediate host, and the other, that of the German school, as recommended by Koch. Continuing, he writes as follows:

"Quite different is Koch's system, which strikes the evil at its roots. Koch fights the cause of the disease, the plasmodium; he seeks to remove it, and in effecting his purpose does essentially nothing different from what has been done with considerable success in other infectious diseases.

"If I am working in the laboratory with a culture and wish to transmit it, I use a platinum point. If the platinum point is taken away from me, for the time being I can make no inoculations, for I must first make a new point. If, on the other hand, my cultures are taken away from me and every crack and corner where these might be is ransacked, and I am deprived of every possible opportunity to make a new culture, then my inoculations are at an end and I can not proceed with them even with the best of points.

"I always use this illustration when I wish to explain Koch's malaria theory. In malaria the mosquito serves as the point, and I no sooner kill thousands of them than hundreds of thousands again appear.

"The reagent glass, the holder of the culture, is the person; the nourishment (agar, bouillon, etc.) is the blood. R. Koch puts into the reagent glass (the human being) a disinfectant (quinine) and the culture is destroyed. If, then, I disinfect everybody who has been inoculated with the virus of malaria, all the cultures are destroyed, and no matter how much virus (blood) the point (mosquito) takes from the reagent glass (human being), the transmission of the disease is no longer possible. Could anything be simpler and at the same time more effective? Is it not, therefore, an outrage and a shame that even in our day civilized nations place their hands in their laps, at the most raising themselves to a few efforts, while they allow their subjects to die before their eyes.

"Should not Koch's results, then, be applicable to mal de caderas? We know that the blood of horses suffering with mal de caderas harbors parasites. We know further that the infection is transmitted only through the bite of a blood-sucking insect. We also know that the infection occurs during times of rain and flood. And, finally, we know that the virus maintains its vitality in horses for from two to five months, and in donkeys and mules as long as one year, and can nearly always be detected during this time.

"In malaria the conditions are such that we must seek the proper host in the human being, and in the mosquito the intermediate host. In the human being the virus maintains its vitality for years, but in the mosquito only a short time. Evidently the conditions are very similar in mal de caderas. We have not yet discovered the intermediate host, but we presume that it is a blood-sucking insect, while the horse is the proper host. I draw this conclusion from the fact that in the case of the horse, and especially in that of the donkey and mule, sick animals are found throughout the year. Virus can be obtained at all seasons, although the disease occurs periodically, a fact which can be attributed only to the periodical appearance of the intermediate host (insect). With a knowledge of the intermediate host this would be still more evident, but for our object we really do not need this. Its periodical appearance is one of the most favorable preliminary conditions possible for a successful fight against the epidemic.

"We shall next state that there are certain periods, dependent upon the rains, during which the transmission of the disease through the intermediate host does not occur. The virus exists then only in the proper host. * * * The rainless season is the period of which we should take advantage to destroy the *Trypanosoma*, for it is then that their distribution is most confined.

"For our purpose we need only two things, first, a means of detecting the presence of the *Trypanosoma*, and, secondly, a disinfectant with which to destroy them. The second thing we do not yet possess, at least not one that will work in the same manner as quinine does in malaria. There remains only one possible solution, that is to destroy the *Trypanosoma* cultures; in other words, to kill the diseased horses.

"This measure is radical and yet very practicable, for such horses are of no value, and this is almost universally true with native horses, for when once sick, a horse may as well be considered lost, and it is useless to continue feeding him. Thus, if we have killed all the diseased horses, mules, and donkeys during the season which is free from the epidemic, when, with the beginning of the rainy reason, the intermediate hosts return, there will be no more *Trypanosoma*, and the disease will at once have been stamped out, just as Koch exterminated malaria by poisoning the plasmodia with quinine. This is not only possible, but absolutely certain. It depends on searching out all the animals having *Trypanosoma*. If the rainy season were longer, most of the animals affected with mal de caderas, at least horses, would die. Donkeys and mules, however, would continue to live; but they show signs of weakness so early that it would be easy to pick them out and render them harmless."

Kimmerich, according to Voges, successfully combated the disease on his estate by converting the marshy regions into open ponds. He considered running water harmless. A South American company using a large number of horses lost annually the larger part of them for two years, the animals being kept in the fields, as is the custom there. Stalls were then built and the horses were kept and fed in them, as a result of which the epidemic disappeared. If infected herds are removed to high, dry grounds, the disease generally ceases. Horses quartered in stalls seldom contract it. The influence of stalling animals on the suppression of the infection is mentioned also by writers in India and Africa.

So far as we have been able to determine, Java is the only country which has adopted and enforced regulations for the suppression of the infection, and as a result the disease is well under control in that country.

Referring to the statement that it is impossible to destroy biting insects, Schat (Java) says:

"It is the opinion of Voges that blood-sucking insects are the carriers of the infection, but he has not proved it, probably because he considers the destruction of the insects as impracticable. Contrary to his opinion, we think it both desirable and possible to do so; nor is the measure to be left out of consideration. To search out all the hosts—that is, the animals suffering with chronic surra—is, in the Tropics, where sufficient expert assistance is lacking, not yet entirely feasible, the more so since Doctor Bruce, of South Africa, has found that the tsetse fly may become infected by sucking the blood of wild animals. The detection and destruction of all infected animals is therefore, under the circumstances, almost impossible in the Tropics. We should look for other measures, such as to insure the cooperation of the owners of cattle and, in general, of all laymen. We should make warfare on all flies found on horses and cattle.

"In the prevention of an epidemic of surra by veterinary means, the three following measures should, in our opinion, be particularly observed:

"1. Limit the extent of influence of the flies which carry the infection.

"2. Protect the sick as well as the healthy animals from the bites of flies in places infected with the disease.

"3. Destroy the hosts—that is, the diseased animals—or else render them harmless.

"These measures alone should have a good chance of success, if the following rule of preventing the spread of an infectious disease at its first appearance is observed. The rule may be given as follows: Whenever an infectious disease appears, the cases of sickness and death should be reported as soon as possible. This applies to all infectious diseases in general, but it is particularly necessary in the case of surra, because its detection is often difficult and requires a great deal of time.

"Let us now, with special reference to surra, discuss the three above-mentioned measures, one by one, and with more detail.

"*First measure.*—To limit the extent of influence of the flies which carry the infection. Whenever a case of surra is determined by the clinical symptoms or by the discovery of *Trypanosoma* in an examination of the blood, or by animal experiment, the sick animal should first of all be isolated, or killed and buried. The animals which are kept on the same ground as suspects should not be transferred to any other place. In this way a spread of the disease as well as of the flies found on the animals will be prevented, for, as is known, flies swarm with horses and cattle when they are quickly removed.

"For the purpose of making it as certain as possible that no infected flies shall be transferred to other places in this manner, the transfer of cattle from grounds bordering on those where surra has been discovered, should be forbidden. This measure may, according to the circumstances, be extended to the entire inhabited part of a district or to a portion of it. In short we would recommend the prohibition of the importation, exportation, and transference of cattle, etc., in the inhabited part of a whole district or in portions of it.

* * * * * * *

"*Second measure.*—To try to protect the sick as well as the sound animals against the bites of flies.

"The sick and the healthy animals should be separated as quickly as possible and transferred to dark, spacious, well-ventilated stalls, since experience proves that in dark places, few, if any, flies are found.

"This precaution the inland cattle owner can take without great trouble. Furthermore, the greatest cleanliness should be observed in the stalls, although this would appear to be very difficult in the villages here, even with the greatest perseverance. The fecal matter should immediately be removed and collected in one place, not too close to the cattle stalls, in order to combat not only the flies but also the larvæ; we know that the larvæ of the *Stomoxys* live mostly in manure, where they develop into a light reddish-brown chrysalis, from which after from four to six weeks the young fly appears.

"It might, perhaps, be recommended that the leaves, pieces of wood, etc., found on the spot where a case has occurred be collected and burned. This should be done in the morning, on the wind side of the kraal, so that the smoke will drive away the flies, which appear on the animals just at this time of the day, in order to suck themselves full of blood.

"Whenever, in the rainy season, the smoking of the stalls in this manner becomes difficult or impossible, the same purpose may be accomplished by placing earthen or iron pans in them, burning damp wood, leaves, etc., in the containers; the cattle owner may also easily make use of ash water, with which he will be able to keep the flies from his cattle. In catching flies the inlander can, without much trouble, make use of sticky twigs; there will always be found on his ground a plant which produces one or another kind of gum or other viscous substance (getah). Getah, mixed with some kind of a treacle (tetes), smeared on a piece of paper or stick of wood, and hung up in the cattle stall, serves the purpose very well.

"*Third measure.*—To destroy or render harmless the hosts of the infection, i. e., the sick animals. * * *

"Thus far we are obliged to resort to a very radical measure, that of destroying the infectious material in as short a time as possible, i. e., killing the sick animals.

"On the outbreak of an epidemic of surra, so long as another and less costly measure is wanting, authority should be requested from the head of the provincial government to take possession of animals sick with the disease and to kill them, in the hope of checking its spread from the very beginning. If, however, too large a proportion of the animals have become infected, so harsh a measure could hardly be carried out; but we would suggest in that event that the spread of the infection may to a large extent be prevented by a strict isolation of animals in spacious dark stalls where great cleanliness is observed.

"I wish also to call attention to the following point: In the blood of emaciated animals we repeatedly found *Trypanosoma*, while clinically individuals suffer with emaciation for a considerable time, without showing, however, any other single definite symptom. It is just these animals from which a spread of the disease through flies should be feared, since we have been able to determine that whenever such chronic sufferers from surra die, their blood contains large quantities of parasites. In the eradication as well as in the prevention of surra it is therefore of great importance to know this fact, in order that the emaciated animals in the district may be looked after. Since this is so, and since in the examination of the blood of these animals surra parasites appear to be present, these hosts of the infection should first of all be rendered harmless.

"Our purpose is only to put these rules in such a form that they may best be applied to the purpose in view; that is, the prevention of surra."

Some of the earlier recommendations for the suppression of the epidemic in the Philippine Islands were not only unsatisfactory, but dangerous. Smith recommended isolation of sick animals at a distance of one-half mile.

Curry, in his original communication, recommended (1) the isolation (at least one-half mile) of infected animals, (2) the protection of infected animals from flies, (3) the protection of healthy animals, and (4) the keeping of flies out of stables. Early in 1902 proper advice in regard to measures for the control of the epidemic was given to the public by the government laboratories in a popular article in the Spanish press.

In a later publication Curry realized fully the weakness of his first recommendations, and made additional suggestions which, had they been followed at that time, would have resulted in the saving of millions of dollars to the country. In substance, these were the destruction of all infected animals and of as many flies as possible, and the protection of healthy animals.

Considerable delay in establishing rules which will control the infection here and which eventually will of necessity be adopted, has been occasioned by efforts to minimize the importance of the agency which flies constitute in the transmission of the disease and to push forward the untenable theory that food and water are infecting agents.

In the absence of any general plans and recommendations from the authorities, misguided local efforts have been made in communities, causing unnecessary expense and trouble and utterly failing to accomplish the purpose for which they were intended. Several municipalities have absolutely forbidden the use of native feed for animals and have promulgated long, useless rules for isolation, etc.

A set of rules which was adopted by one of the provincial boards of health and which was sent to us for remarks is as follows:

"1. All sick horses must be isolated to a pasture separate from the rest of the herd.

"2. Inspections must be made daily and sick horses transferred to isolated pastures.

"3. The bodies of dead horses must be burned or buried in trenches at least 10 feet in depth.

"4. Those who attend to diseased horses must not take care of other horses.

"5. No efforts must be made to preserve the hides of diseased horses, for their sale will not be permitted.

"6. The pasture used for diseased horses shall not be used for other horses or cattle for a period of two years after the epidemic.

"7. Diseased horses shall not be watered in running streams, nor shall they be bathed in streams or rivers used for other horses."

Of course such rules need no comment. They show, on the other hand, that the intelligent element of the country is aroused to the necessity of doing something, and not knowing just what is best, follows out the dangerous suggestions of the earlier writers in regard to the epidemic in these islands. These are, however, in substance the antiquated ones of literature. In the face of all this it behooves us to reach the root of this subject for the information of the better classes, and to suggest regulations which will place the execution of efficient measures in the hands of the proper officials.

We have already dealt with the methods for preventing infection in a virgin country and reinfection in countries where the disease is already prevalent, and will now take up the discussion of methods looking to the control and suppression of surra in our own country. To be fully efficient, recommendations must, of course, be practicable and of such a nature that the cooperation of the public may be obtained. The necessary considerations are:

1. The destruction of all infected animals—
   (*a*) Animals of economic importance.
   (*b*) Rats and mice.
   (*c*) Game and other wild animals.
2. The destruction of biting insects.
3. The protection of contact animals from flies during the incubation period.
4. Miscellaneous measures.

First.—The destruction of all infected animals would make other measures unnecessary; but this offers so many difficulties, especially in the provinces and outlying districts, that it will be found advisable to reinforce this measure by the other methods discussed.

(*a*) *Animals of economic importance.*—In Manila and other cities with organized sanitary corps diseased animals should be located without any difficulty. To do this to the best advantage and to make the work systematic necessitates that the whole matter be placed in the hands of a single bureau, and that bureau should of course be the insular board of health. Other points in the accomplishment of this task are matters of detail, which may readily be solved by the board of health. There can be no question that this matter properly belongs under the control of the sanitary bureau, just as do the infectious diseases of man. In fact, as already shown, there have been 16 cases of trypanosomiasis in man and the chances are that many more will be found.

The work of detecting all diseased animals will necessitate some kind of a systematic inspection, which may easily be carried out in Manila and other cities by those charged with such duties in guarding the public welfare. In addition to the daily inspection by sanitary inspectors of all horses found in stables, all other officials, such as medical, veterinary, and police officers, might be required to report all sick animals coming under their cognizance to an official of the board of health.

How best to secure the cooperation of the general public in reporting sick animals is a problem open for discussion. Several officials interested in this work have suggested the advisability of the government's buying all sick animals, arguing that a reasonable offer would cause all such to be brought in and thus prove economical in the end, whereas, if coercion were attempted, the more ignorant people would hide their animals for days and probably for weeks before they could be found by the authorities, thus adding materially to the spread of the disease. This argument has something in its favor, but it seems to us on the whole a dangerous policy—the purchase of good citizenship—which, although it might give immediate results of a temporary nature, would in the end prove unsatisfactory. The purchase of superstition or malice, whether it be with candy in the case of children or with money in that of adults, and whether in the schoolroom or in the municipal office, invariably leads to disaster.

It appears to us that the recommendations made should be just and equable, and such as will be supported by the intelligent part of the community and in the end will result in the elevation of the standard of citizenship of the ignorant. Undoubtedly right demands the cooperation of the public in such an undertaking, and we believe that the law should require owners, agents, and custodians of animals to report those sick and that the failure to do so should be punishable by law.

The manner and time of inspections and the reporting of sick animals in cities are matters of detail, which need no discussion here, while rules applicable to the provinces and outlying districts may be drawn up to meet conditions. The methods best adapted for searching out the infected animals may be subject to discussion, but the disposition of them when once found does not admit of argument. There is only one thing to do with a horse suffering from trypanosomiasis, and that is to destroy him immediately. To do this efficiently and quickly necessitates the placing of authority in such a manner as to avoid the loss of time.

Immediately after the death or destruction of an animal suffering from this disease, the body should be protected from flies, and other insects, and disposed of as soon as possible. This may be done in one of several ways. In cities, probably the most satisfactory way is to take the body to the crematory in a fly-proof wagon and have it burned at once. Where means for such disposition are not at hand, which is generally the case in rural districts, the body may be buried at a sufficient depth to keep dogs and flies away from the carcass for forty-eight hours, or it may simply be protected by mosquito netting, or otherwise, for the same length of time, and then disposed of in any sanitary manner.

It is well to call attention to the care which should be exercised in performing necropsies on animals dead of the disease. This should either be done under protection from flies, or, if this is not practicable, all living animals should be removed from the immediate vicinity and kept away for forty-eight hours. In any event, the blood, organs, etc., should be protected from flies and dogs, in the same manner as the whole body, for from twenty-four to forty-eight hours.

(*b*) *Destruction of rats.*—There is no longer any doubt that a certain number of these pests harbor *Tr. evansii*, and that they have a practical significance in the spread of the disease. The annual destruction of thousands of them in Manila, on account of the plague, as already mentioned, will no doubt reduce the danger of the spread of surra from this cause to a minimum. In the provinces, and cities, however, where this wholesale destruction is not carried on, the importance of looking after this work with especial reference to surra is more urgent.

Fortunately, whether in the city or in the country, great difficulty is rarely experienced in destroying large numbers of rats by poisoning; and it is recommended that such a procedure be carried out as a matter of routine in methods adopted for the control of the disease under discussion.

(*c*) *Destruction of game and other wild animals.*—In other countries, the spread and perpetuation of the infection is undoubtedly carried on by wild animals, and if our work in stamping out the infection here is not prompt and vigorous it will in all probability become one of the conditions that we shall have to face here later on, if it does not already exist to a limited extent. This is a matter to be kept constantly in mind in dealing with this disease, and our plans might well be broad enough to cover this point. This source of danger will, even under the most favorable conditions, rarely become a great menace in cities, but some precautions are nevertheless necessary.

A law which will prevent the reinfection of the country by such animals is of the highest importance. With the prohibition of the admission of circus and other wild animals, except under certain regulated conditions, there still remain for consideration the public animals of our parks. While the disease is constantly prevalent in Manila there is nothing to prevent some of the animals in the Zoological Garden from contracting it, and on account of the harmlessness of the infection in these animals, they might become an indefinite focus for the diffusion of the disease. It seems to us that the easiest and most practical way of avoiding this danger would be to inclose all such animals in fly and mosquito proof screened areas, as is now being done in many of the large zoological gardens in other countries. Researches of recent years have shown the necessity of this precaution, since many wild animals act as hosts for other parasitic diseases communicable to man, which need not here be discussed.

2. *Destruction of stinging and biting insects.*—As has already been stated, if the destruction of infected animals (the hosts) were carried out systematically and with thoroughness, flies and other insects as carriers of the infection would be harmless. While we have sacrificed the ideal in the disposition of infected animals to the practical, as far as possible within the limits of efficiency, we fully realize that conditions may make still further sacrifices necessary. It is principally for this reason that we have taken up the consideration of auxiliary measures to supply what may necessarily be lost in the efficiency of the more desirable ones.

Insects are becoming of so much importance in the propagation of other diseases, both of man and of animals, especially in the Tropics, that we are urged to recommend their partial destruction on account of surra with more assurance, knowing that the fulfillment of our hopes would be a distinct step in advance in preventive medicine in general.

To illustrate what we shall some day be compelled to face here, the best medical thought of Europe and America is already concerning itself with the effect which fast travel to the Orient is likely to have upon the introduction of yellow fever to this part of the world. The proposed interoceanic canal has brought this subject afresh before the world. The mosquito of yellow fever is one of the most common in the Philippine Islands, and with the shortening of the voyage from fever-infected countries by the proposed canal, and, for that matter without the canal, by the increased speed of our modern ocean-going vessels, the time required to travel from those countries to the Orient will be brought within the limit in which the disease may be transmitted. Without dealing further with present and prospective problems, depending, to a certain extent, upon the disposition of certain insects for their solution, we shall resume the discussion in hand.

The most important insects to be destroyed, because of the part they play in carrying surra, are the biting flies. To accomplish this in the most extensive manner, and with the least amount of work, resolves itself into the destruction of their breeding places by the proper disposition of fecal matter. As has been recommended by various writers, this may best be done by burning all offal during the dry season. Methods upon a smaller scale looking to the same end are too well known to need discussion here. Cleanliness around livery stables and large corrals belonging to the government and to other persons is particularly desirable, because it is naturally in such places that the danger is the greatest on account of the close proximity of the animals and the large number of flies usually found there.

Recommendations and methods for the destruction of mosquitoes are so recent and so well known that this part of the subject may be omitted.

The destruction of fleas, which are second in importance to flies in the transmission of surra, is, so far as we are informed, an unsolved problem.

3. *Treatment of contact animals.*—The blood of an infected animal is infectious before the symptoms are present, or parasites found in the blood by microscopic examination, so that the necessity of protecting contact animals during the incubation period of the disease is evident.

There are several ways of accomplishing this. When surra is found in a stable, contact animals should be quarantined where they are, for at least seven days. The diseased horse, after removal, should be protected from flies during the first forty-eight hours, and if several are present they should be protected from each other. Where there are only one or two diseased animals, they may be protected by mosquito bars, by smearing with iodoform ointment, washing with solution of creolin, burning smudges in the stables, or by other well-known methods. Where there is a large number, as in a livery stable, it will be found easier to destroy or remove the flies by smudges, darkening of the stalls, etc.

All rats around such places should be poisoned and the general sanitation, especially with reference to breeding insects, should be improved.

Temperatures of all contact animals should, of course, be taken twice daily during the incubation period, and the animals should be carefully examined for other symptoms. It is hardly necessary to repeat here that as soon as an infected animal is found it should be destroyed.

4. *Miscellaneous measures.*—Musgrave and Williamson, in a preliminary report, offered the following suggestions to owners of private stables or individual horses.

"When using the animals in the daytime, as much as possible avoid allowing a horse to stand in a group of other horses. To illustrate: Only a few days ago, we observed standing in front of a Government building some thirty or forty horses, and one of them, hitched to a public carromatta, had a well-advanced case of trypanosomiasis. Should such a thing happen during the season of biting flies, the danger of infection to all would be very great.

"Stables should be kept scrupulously clean and well ventilated and excreta and waste should be promptly removed.

"All sores of whatever character on horses should be kept covered with a suitable ointment to keep off the flies.

"Especially valuable horses may be provided with screened stalls.

"There is no conclusive evidence, so far as trypanosomiasis is concerned, of any danger from allowing horses to drink the city water or to eat food supplied in the Manila market.

"Upon the appearance of illness in a horse a competent observer should be asked to examine the animal."

All kinds of sores on animals should be kept covered with tar, iodoform ointment, or some other substance disagreeable to insects. The legs and edges of the hoofs should be carefully looked after. Rats should be kept away from stables by systematic poisoning or should be caught with traps. Other little points worth looking after will suggest themselves to the thoughtful mind.

That from which the public in general will derive the greatest benefit, and which will give results to every stock owner, is the moral support of the officials intrusted with the handling of this problem.

SERUM THERAPY.

In this day of scientific advance in medicine, the trained mind naturally turns to the possibility of preparing prophylactic or curative sera for disease, and as all other remedial measures have proved a failure in surra, this seems to be the only hope. Considerable work in this direction has been done during the past few years, and while as yet not successful, the outlook is not altogether discouraging.

Koch professed to have established a successful method of preventive inoculation based upon the attenuation of the parasites by successive passages through other animals. His experiments are given as follows:

"On the 8th of September, 1897, there were inoculated with the defibrinated blood of an ox, rich in *Trypanosoma*, the following animals: One ass of Massai, one cow, two calves, two monkeys, two guinea pigs, two rats, and one dog. The ass of Massai, the monkeys, and the guinea pigs remained in good health; no sign of infection was observed in them. The cow died at the end of thirty-nine days, the calves at the end of forty-one and forty-nine days, the rats at the end of thirty-four and fifty-two days, and the dog at the end of nineteen days.

"On the 15th of October, 1897, the blood of one of the rats inoculated on the 6th of September was injected into two rats and one dog. One of these rats was found dead six days after inoculation, showing the appearance of *Trypanosoma* in the blood; the second rat showed *Trypanosoma* thirteen days after inoculation but did not die until sixty-eight days thereafter. The dog died at the end of forty-two days, and its blood was utilized for the third passage.

"On the 30th of October there were inoculated with the blood of the dog, two dogs, two oxen, four asses of Massai, and three rats. The dogs died after nineteen and twenty-six days, the rats at the end of sixty-seven, seventy-three, and eighty days; and the asses were not infected."

Laveran and Mesnil criticise Koch's work, stating that a certain percentage of cows are known to recover from both nagana and surra, and that the attenuation of *Trypanosoma* by successive passages through different species of animals is very slight.

Nocard immunized a calf that had recovered from nagana with increasing doses of virulent blood until it had received 850 c. c. in all. The animal was then proved free from infection by animal experiment, but its serum had neither preventive nor curative properties in mice, and mixed with infected blood produced the disease with a prolonged incubation. This serum was very agglutinative for *Trypanosoma*.

Rost gave a pony sick with surra 10 drops of normal goat blood subcutaneously, and 10 more drops four days afterwards in the same manner. A temporary diminution of the parasites and a fall of the temperature followed each injection.

Another pony, which had the disease in an advanced form, was given 20 drops of mule's blood by subcutaneous injection. The parasites temporarily disappeared, but returned in greater numbers, and the animal died on the fifth day after inoculation.

Another pony infected with surra, and the blood of which was rich in *Trypanosoma*, was given subcutaneously 30 drops of the blood of a goat which had recovered from a single injection of surra. The parasites temporarily disappeared. Another injection was given on the twenty-third day, and a temporary disappearance of the parasites again resulted. On the twenty-eighth day the parasites were again numerous, and another dose of goat serum, which had been highly fortified by injections of surra blood, was given, followed by another fall of temperature and the permanent disappearance of the parasites. The animal continued to grow fat, but on the twenty-third day after the last injection the temperature again rose, and death finally occurred from tuberculosis.

Sterilized filtered goat serum caused a temporary disappearance of the *Trypanosoma* in a horse sick with surra, but the disease followed its regular course and the animal was shot before death. Ten mules were treated with serum without encouraging results; in fact, the contrary was true, for Rost concluded that the sterilized serum of immunized goats produced exacerbations of the disease in mules.

His best results were obtained from normal or slightly fortified goat's serum, for the more highly he immunized his goats the worse were the results obtained. He immunized a goat with surra blood taken from the same species of animals which he afterwards treated with the serum, and during a period of eight days he sterilized it daily for four hours at 57° C. He says that the immunized goat's serum killed surra parasites under the microscope.

Voges inoculated a cow for eighteen successive months with virulent blood, but the serum obtained from the animal was worthless, either as a preventive or curative.

In Schat's work the serum obtained from cows which had recovered from surra was injected into other cattle and into rabbits, and in some cases it seemed to exercise certain preventive and curative influence on the disease.

He immunized a cow against *Trypanosoma* by increasing doses of defibrinated blood during a period of two months. The serum obtained from this cow was injected in doses of 10 c. c. into two calves known to be nonimmune. Twenty-four hours after the last injection of serum the animals were inoculated with surra blood. A control was inoculated at the same time. On the sixth day parasites appeared in the blood of all the three animals, disappearing from that of the immunized calves at the end of four days and from the control at the end of five days. The protected calves returned to health, but parasites again appeared in the case of the control, and the latter went through the regular course of the disease.

A rabbit was protected by 5 c. c. of the same serum, with only a temporary appearance of the parasites. Three rabbits were inoculated with mixtures of cow's serum and blood containing *Trypanosoma.* One of them developed the disease, while the other two, where the mixture was kept for five to fifteen minutes before injection, did not contract the disease.

Laveran and Mesnil, experimenting mostly with mice and rats and a few dogs, state that human serum injected in sufficient quantities shows manifest action on the disease. *Trypanosoma* disappear from the blood at least temporarily, the evolution of the disease is retarded, and sometimes a complete cure results in the case of mice and rats. The serum of adults is more active than that of children and maintains its activity for a considerable time when preserved aseptically. Pleural effusions are less active than the serum from the blood, while the activity of ascitic fluid is still less. In infected mice they used doses of 0.5 to 1 c. c., and in rats doses of 1 to 2 c. c., which caused a disappearance of the parasites in eighteen to twenty-four hours after infection.

They had four successful cures out of a very large number of rats and mice so treated, and in all of these cases it was obtained after one or two injections. In those animals from the blood of which the parasites disappeared only temporarily, they were caused to disappear time after time by repeating the injection, and if they recurred after the first injection a complete cure was never produced.

By alternating the injections of human serum with arsenic the influence exercised on the longevity of animals was still more favorable, but there were no complete cures. One rat so treated lived for one hundred and twenty-seven days and a mouse for one hundred and three days.

Human serum was determined to be just as active for mal de caderas as for nagana, but *Tr. lewisii* was unaffected by the treatment. The sera of birds, chickens, and geese, highly fortified with *Trypanosoma* blood, had no curative power. Large numbers of sheep, cows, and deer recover from nagana, but their sera fail to show either preventive or curative properties, and do not acquire them when immune animals are further protected by large doses of virulent blood.

According to these authors, sheep, deer, and cattle which have recovered from nagana possess an active immunity to this disease.

Human serum has a very weak preventive power. Mice given 1 c. c. of blood mixed with 4 c. c. of human serum show no infection. Sometimes this result may be obtained by injecting serum and blood simultaneously in different parts of the body. If, however, the serum is given twenty-four hours after the virulent blood, the disease appears, the only result noticed being an increase of from five to nine days in the length of the incubation period. If human serum is injected first and infected blood twenty-four hours later, the infection, as before, takes place with a prolonged incubation. In those mammals which do not contract the disease by the injection of human serum and infected blood an active immunity is established.

The sera of dogs, sheep, deer, horses, geese, and chickens, when mixed with trypanosomatic blood, are still infectious, and the disease runs the regular course with a normal incubation. The sera of animals that have recovered from nagana are without value as either preventive or curative agents in the disease. The serum of sheep which have recovered from nagana, and have afterwards been further immunized, shows neither preventive nor curative properties. Fortified sera from the chicken and the goose are worthless as a means of prevention. Chicken's serum mixed with equal parts of infected blood killed a mouse in fifteen days, while a control lived for seven days.

Strong, commenting on Laveran and Mesnil's work, writes: "We had already previously tried injections of human blood into monkeys suffering from experimentally produced trypanosomiasis from injections of *Trypanosoma evansii*, but found, while the parasites disappear temporarily, after a few days they were always again present in the circulating blood. Goat's blood and bile from monkeys that had died of the disease were also tried, but with like results. Goat's serum was used, as these animals are relatively immune to the parasite. Experiments with the intravenous injection of benzoyl-acetyl peroxide will be performed as soon as the animals for experimental purposes can be secured."

Laveran and Mesnil also showed that infected blood kept on ice or at the temperature of the room until the death of the parasites has almost resulted, is still infectious, producing no change in the course or the duration of the disease, excepting a prolongation of the incubation period. Similar results were obtained with blood heated to different temperatures for different periods of time. The addition of toluidin blue to infectious blood, in the proportion of 1 to 100 parts, did not modify its virulence, except to prolong the incubation.

They passed *Trypanosoma* through sheep six times and then through a dog, but the blood remained just as virulent for rats and mice as the original control. They failed to confirm Schilling's and Koch's work. The difference in action between their *Tr. brucei* and that of South Africa may be owing to the difference in species of the cattle or to an attenuation of their virus. They suggest the possibility of obtaining practical good by infecting the South African cattle with the milder *Tr. brucei* from which a large percentage of Paris cattle recover.

Laveran and Mesnil come to the conclusion that all attempts at prevention or cure have, for practical purposes, been negative, and that prophylactic measures which may be found of service in one form of trypanosomiasis will probably prove equally efficacious for all.

Schilling states that he attempted to attenuate the parasites by passing them through different animals. He inoculated three horses with *Trypanosoma* which had passed through five dogs. They all contracted the disease and died. He then inoculated two horses with *Trypanosoma* after eight passages through dogs, as a result of which they both contracted the disease and died. Parasites which had been passed through four cows were still virulent for the horse.

In a second paper Schilling writes that he immunized a bull which had recovered from surra. Parasites were found in the blood from nine to twelve days after the first injection of 10 c. c., but none were found after the second of 19 c. c., which was given in the abdominal cavity a month later. A month after this injection the serum in thirty-one minutes killed the parasites in the hanging drop. Further immunization for two and one-half months did not make it more effective in vitro, and when employed in treatment it was useless. After about eight months the animal died of hemorrhagic enterocolitis, but *Trypanosoma* were not present.

Schilling simultaneously inoculated three calves with the peritoneal exudate of a dog which had been infected by an abdominal inoculation of *Trypanosoma* after they had been passed through the peritoneum of other dogs. After twenty-one, twelve, and fifteen days, respectively, parasites were no longer found in these calves. The serum showed no reaction with *Trypanosoma*. These animals were then transferred to an infected region, one dying during transportation, while the other two were well at the end of three months.

The same author immunized a steer in a similar manner, except that as a first inoculation the peritoneal exudate of a dog inoculated directly from a horse was used, and a like injection was given sixteen days after the first. Five days after the first injection the serum showed no reaction with the *Trypanosoma*, but four days after the second one it agglutinated them, only a few motile ones being left at the end of thirty minutes.

Two young steers were immunized with doses consisting of from 3 to 10 c.c. of the peritoneal exudate of dogs which seven days before had been inoculated in the abdominal cavity with virulent blood. On the fourteenth and fifteenth days after the last injection the serum of both these steers showed marked antiparasitic action on the *Trypanosoma*, killing them in thirteen to twenty-five minutes. Parasites were absent in both of these animals.

Schilling later immunized 36 cattle with the peritoneal exudate of dogs which had been given intraperitoneal inoculations of *Trypanosoma* attenuated by passing them through 7 dogs and rats and then through 18 to 21 dogs. The peritoneal exudate of dogs used on cattle always showed numerous *Trypanosoma*.

Of 24 cattle 12 showed parasites in the blood on the tenth day after inoculation. The number in all of these cases, however, was very small, and in 10 animals they disappeared in from one to two days. In one out of nine cows one *Trypanosoma* was found in a preparation made on the ninth day after the second inoculation, while the others were negative. The temperature rose to 40.3° C. on the fifth day after the first injection in the case of one of these animals, but it fell to normal within three days. On the same day a single parasite was seen, but after that none were to be found; indeed, following the second injection of large numbers of *Trypanosoma* the temperature remained normal and parasites were constantly absent from the blood.

Eight of the animals previously used were examined (subsequently to the last injection) to determine the parasiticidal power of the blood serum. In five cases the parasites were killed in twenty minutes, in one the reaction was very weak, while in two there was no reaction whatever. What the factors in the production of such differences were, he could not then say because of the limited time and the small amount of material at his disposal; he believed, however, that the cause lay neither in the quantity of injected parasites nor in the time which had elapsed between the first and second inoculations.

Of the animals used 19 remained in Sokode, 9 were taken to the station of Ataxpane, and 8 to Mishohe and the experimental station of the cotton expedition of the Colonial Scientific Committee in Tove—all places at which during the year before animals had died of surra. According to reports, at the beginning of October the inoculated animals were well, and in Tove 5 oxen were doing their usual work in the fields. The time had not been sufficiently extended for him to come to any definite conclusions.

In Sokode, Schilling found a naturally infected ass, which he watched for twenty-five days. It has already been stated that the ass of Soudan is susceptible to surra. Attention should here be called to the fact that there are some racial differences between these asses and those of East Africa with which Koch worked, and which he did not succeed in infecting. In one of his experiments, however, the inoculation of surra blood into a small wound in the skin of the ear proved negative. Passages of blood taken from the naturally infected animals mentioned above were made through several asses by the subcutaneous injection of large doses. Altogether 5 animals died between the eleventh and fifteenth days after inoculation, with all the symptoms of a severe general infection (fever of remittent type). Post-mortem showed nothing that might be called typical. The parasites increased very rapidly (incubation about four days), reaching enormous numbers. From this we may conclude that the Soudan ass is even more susceptible than the horse.

This writer inoculated the parasites obtained after passages through 5 asses into a small, healthy horse. The animal suffered an acute attack of surra, but the course was somewhat unusual. According to a letter received from Doctor Kersting, the animal was fairly well on the twenty-first day after inoculation. On the eighteenth day no parasites could be found.

He believed that the principle of successfully immunizing animals against the African tsetse-fly disease (nagana) had been discovered. The peculiarities of the nagana parasite with reference to its ever-present host, were utilized in weakening its virulence for certain kinds of animals.

In looking over literature carefully one is struck by the relative immunity to surra of certain animals that are susceptible to other diseases.

Mr. Harford, His Britannic Majesty's consul to the Philippine Islands, informs me that when he was stationed in Africa it was a recognized fact that "salted" animals were less susceptible to the bite of the tsetse fly than others, and that the Government paid increased prices for such animals for the African service. By "salted" horses are meant those that have recovered from a peculiar disease of horses prevalent in Africa, and by "salted" cattle those that had recovered from rinderpest.

G. H. Evans, quoted by Lingard, says: "The gaur (Indian bison) and tsaing suffer from rinderpest and foot-and-mouth disease, yet these animals have not up to the present time been observed with surra, although a careful search for the disease has been made. They live in a jungle where the flies are so annoying to them that they have to go into the open to escape their attacks."

In India a large percentage of cattle are "salted," that is, they have recovered from rinderpest or from the "serum simultaneous inoculation method" against rinderpest, which when successful results in a mild attack of the disease.

These points, and the fact that the injection of rinderpest blood into dogs prolongs the incubation period somewhat, suggest a possible antipathy between surra and rinderpest. We have performed a number of experiments fully to determine this matter, and have come to the conclusion that animals suffering from rinderpest or recovered from it are just as susceptible to surra as others.

The attempts of Schilling, Koch, and others to attenuate the parasites by methods already described, in which they believe they have succeeded, have been repeated by us, but we have been unable to verify their conclusions. In fact, we have failed to attenuate *Trypanosoma* by any of the methods employed. Attempts of all conceivable kinds have been made to immunize animals, but usually without success.

In the beginning of our work, when we were less familiar with our subject, we believed that we had immunized a goat, because parasites could not be found in the blood; but it was later discovered that the blood was infectious by inoculation.

We have succeeded in bringing a cow up to the point where the injection of 3,000 c. c. of blood produced but little effect, although it contained large numbers of *Trypanosoma*. This animal was infected and ran a chronic course after the first injection of 10 c. c., and the blood remained infectious until about one month after the last injection of 3,000 c. c.; but since that time, now three months ago, the blood of this animal has not been infectious by inoculation, and it has fattened and appears to be in perfect health. Serum taken from this cow at different times has been absolutely valueless either as preventive or curative in several species of animals.

Similar negative results have attended all our extensive work. We have followed the suggestions of others and have conducted many original experiments, but we have had no results which seem to offer hope for either a preventive or a curative serum.

TREATMENT.

Many drugs have been used in attempts to cure this disease, but so far without results offering any hope for future work along this line.

Braid, in a letter written in 1858 to the British Medical Journal, suggested the use of one to two grains of arsenic daily in cattle suffering from the bite of the tsetse fly. This letter was called to the attention of Dr. Livingstone, and he agreed to follow out the suggestion at the next opportunity.

In a letter to the British Medical Journal, published March 13, 1858, Balfour indorses Braid's suggestion as to the use of arsenic, but recommends Fowler's solution as a more desirable preparation, provided it is used in large doses.

Referring to the letters mentioned, Livingstone himself writes in the British Medical Journal, May 1, 1858, as follows:

"The very same idea with respect to the employment of arsenic in the disease which follows the bite of the tsetse occurred to my own mind about the year 1847 or 1848. A mare belonging to Mr. Gordon Cumming was brought to Kolobong, after prolonged exposure to the bite of the insect, and, as it was unable to proceed on the journey southward, its owner left it to die. I gave it two grains of arsenic in a little barley daily for about a week, when an eruption resembling smallpox occurred. This induced me to discontinue the medicine, and when the eruption disappeared, the animal's coat became so smooth and glossy that I imagined that I had cured the complaint; for after the bite is inflicted the coat stares as if the animal were cold.

"The mare, though apparently cured, continued lean. This I was rather glad of, as it is well known between the latitudes of 20° to 27° S. that when a horse becomes fat he is almost sure to be cut off by a species of pneumonia commonly called 'horse sickness.' About two months after this apparent cure the coat began to stare again, but this time it had remarkable harshness and dryness. I tried the arsenic again, but the mare became like a skeleton, and refused to touch the barley. When I tried to coax her, she turned her mild eye so imploringly, and so evidently meaning, 'My dear fellow, I would rather die of the disease than of the doctor,' that I could not force her. I got her lifted every morning to feed, and saw her at last perish through sheer exhaustion, and this was nearly six months after the bite was inflicted."

Since that time the treatment of trypanosomiasis by arsenic has frequently been mentioned in literature. It has been given in various ways and in all reasonably sized doses, by mouth, subcutaneously, and intravenously. The pure acid as well as many of the salts have been used. Some writers mention its previous use in the treatment of the disease, while others, judging from their writings, thought that they were trying something new.

In a circular letter from the Headquarters of the Division of the Philippines, as late as January 11, 1902, we read as follows:

"The board ordered to inquire into and to investigate the disease of animals called surra have found Fowler's solution of arsenic, given intravenously, to destroy the parasite in nearly every case, and animals so treated are doing well, but such treatment is not as yet conclusive as to cure."

Lingard has given minute directions for the use of arsenic to accomplish the best results. Some writers assert that arsenic delays the course of the disease, and a few that cures may result, but the consensus of opinion is against this, and without doubt justly so. The statement that arsenic destroys the parasite in circulation is without a particle of evidence to support it. That the parasite may not be found by microscopical examination after such an injection is true, but the same results are just as likely to happen after the injection of any other substance; or, for that matter, it is occasionally difficult or even impossible to find the parasite for days at a time, when no treatment whatever has been given. However, it has been shown by others, and the observations have been confirmed by us, that the blood at this time is infectious when injected into susceptible animals, and that in such cases the parasites always reappear.

Laveran and Mesnil conclude that human serum and arsenic are the only substances that have shown any definite activity, and that under certain conditions arsenic may be used to prolong life.

They treated animals sick from nagana with arsenious acid, arsenite of soda, arrhenal, corrosive sublimate, Donovan's solution of arsenic and mercury, potassium iodide, quinine, a solution of arsenious acid, toluidin blue, methylene blue, and several of the newer silver salts, as silver lactate, fluoride, or trachiol, and carseinate of silver, or argonin, without curative results.

They quote Edington as having caused a disappearance of the parasites in sick animals by injecting one part of bile of animals dead of the disease mixed with two parts of glycerin, and state that he obtained immunity in healthy ones. Laveran and Mesnil used this treatment on dogs with negative results. In rats and mice it did not influence the course or duration of the disease.

Bruce used arsenite of sodium intravenously in large doses. He concluded that this treatment would cause a temporary disappearance of the parasites and somewhat prolong life, but that it would not cure the disease.

Lesur employed subcutaneous and intravenous injections of Fowler's solution, cacodylate of sodium, and arrhenal without definite results.

Deixome made use of arsenic, cacodylate of sodium, arrhenal and corrosive sublimate, but to no purpose.

Curry tried quinine subcutaneously and intravenously, methylene blue and salt solution intravenously, arsenic subcutaneously and by mouth, as well as various tonics, iron, cinchona, etc., but the animals died with the usual regularity in spite of treatment.

Schilling determined quinine, corrosive sublimate, and bile to be useless.

Voges used intravenous injections of large doses of quinine and methylene blue, with negative results. He employed also the following without any benefit: Enteral, sodium salicytate, turpentine, potassium permanganate, potassium iodide, and corrosive sublimate. He observed, as have so many others, a temporary improvement under the treatment of arsenic, life being prolonged, but no cures effected.

Three native ponies were treated with daily intravenous injections of large quantities of 1-1,000 solution of acetozone. A temporary drop of the temperature often followed treatment, and, as in the case of almost any kind of an injection, the parasites sometimes disappeared for a short time from the circulation, but definite or permanent results were not obtained, although the course of the disease was somewhat shortened.

As has already been shown, several substances have a destructive action for *Trypanosoma* in the hanging drop, but no such favorable action was obtained from any of them in treatment, whether by mouth, subcutaneously, or intravenously. The following have been used by us in the treatment of animals ill of the disease, but in none of them with hopeful results:

Tysol, creolin, infusion of pepo, granatum, santonin in the form of freshly prepared santonate of soda, strychnine arsenate, Fowler's solution, spigelia, copper arsenite, pelleterine, eucalyptus, quinine hydrochlorate and urea and combinations of several other salts and quinine, thymol, chloral hydrate, glycerine, methyl alcohol, acetic alcohol, barium chloride, calcium chloride, magnesium chloride, picric acid, oxalic acid, and various strengths of salt solutions alone and in combination with other drugs, carbolic acid, formaline, potassium permanganate, cyanide of potassium, urotropin, turpentine, cuprous sulphate, cupric sulphate, eosin water soluble, eosin alcohol soluble, potassium acetate, potassium chlorate, corrosive sublimate, arsenious acid, methylene blue, and several other aniline dyes.

The following serums have also been used: Antidiphtheritic, antistreptococcic, antirinderpestic, antiplague, antidysenteric, antitetanic, and all available prophylactic preparations.

Toxins, toxic cultures, and fresh cultures of numerous organisms have been used, including plague, dysentery, typhoid, paracolon, Malta fever, streptococcus cholera, and several strains of colon bacilli.

Blood parasites have been inoculated, including malaria and two varieties of filaria.

Extensive use has been made of human blood taken from fresh necropsies and in the following diseases: Cholera, dysentery, plague, malaria, typhoid, Bright's disease, leprosy, and malignant neoplasms.

Blood from the lower animals, both in health and in disease, has been employed; from healthy cows as well as from those suffering from rinderpest and foot-and-mouth disease; from sheep, goats, deer, rabbits, guinea pigs, frogs, chickens, ducks, pigeons, and several other species of animals.

Bile and other excretions and secretions, including urine, from both healthy and diseased animals as well as from those dead of surra, have been used.

Use has been made of the extracts from the lymphatics, the adrenal, and the thymus, as well as from organs affected with surra and other diseases.

Recourse has been had to X-ray and other light treatments, various emulsions and preparations of blood, and attempted attenuations of parasites.

As already mentioned under serum therapy, considerable time has been devoted to the preparation of specific sera; and numerous injections of aspirated serous fluids and the contents of collodion sacs have been kept in the abdominal cavity of susceptible animals for varying lengths of time.

In all this work we have not obtained a single recovery, nor have we been able to bring about conditions that would indicate the slightest hope of effecting a cure in animals when once they have contracted the disease.

In conclusion, we see no hope whatever for curative treatment along lines so far investigated, and the outlook for preventive treatment is hardly more encouraging.

From a casual observation, the conditions seem unfavorable, but if we go more deeply into the matter we find that they are not so bad after all. The disease is one which can certainly be prevented in a country not yet infected, and can as surely be eradicated from one where it is already epidemic by means which are thoroughly practicable. There is presented to us in the Philippine Islands to-day an opportunity to accomplish results which will be gratifying to the scientific world, and which should save the country from the annual loss of thousands of dollars.

SUMMARY AND CONCLUSIONS.

Trypanosomiasis is considered to be a general infection caused by *Trypanosoma*. The term *trypanosomiasis* in a general sense is used to designate all varieties of the infection as found in different animals. The long list of vernacular names now in use, except surra, should be discarded or else allowed to fall merely as synonyms, save in those cases where the infecting parasite is shown to be a species distinct from that of *Tr. evansi*.

A study of the history of the disease shows it to be of remote origin, records of it in some countries dating back for centuries.

It is distributed over large areas of the tropical and subtropical world, corresponding closely in its dissemination to the malarial zones.

Trypanosoma in general are discussed with reference to history; methods of study; general characteristics, including modes of multiplication, agglutination, and involution forms; distribution in the body and outside the body; life cycle.

The life cycle is as yet unknown, but is believed to be acted out entirely within the animal economy.

A tentative classification has been adopted for purposes of study, and each *Trypanosoma* of importance has been discussed with reference to its principal characteristics, habitat, and pathogenesis.

The differential diagnosis of *Trypanosoma* of mammals, like the life cycle, is left an open question, but the weight of evidence in literature and our own observations tend to the conclusion that at least three of the species to which separate names have been given are in reality identical with *Tr. evansi*.

Under the discussion of modes of transmission and infection the only point upon which emphasis need be placed is the conveyance of the disease through wounded surfaces, in which biting insects, particularly flies and fleas, serve as the principal agencies. It is clear that the prevalence of the disease is dependent upon the presence of a host for the *Trypanosoma*, and of insects for their transmission. The animals which serve as hosts for the perpetuation of the disease through the dry season vary in different countries. In Manila sick horses exist in sufficient numbers to carry the infection from one rainy season to another; cows and rats may also aid in its perpetuation.

Statements concerning the infection of pastures and water and the transmission of the *Trypanosoma* through sound mucous membranes have nothing to support them.

After describing the general pathologic anatomy and symptomatology, we have taken up the discussion of the infection in various species of animals, paying particular attention to the disease in those of economic importance. The manner in which the symptoms vary in different animals has made this necessary, in order to enable us to make satisfactory diagnoses and intelligently to control the epidemic.

The course, the duration, the prognosis, the complications, and the diagnosis have all received a general consideration.

A chapter has been devoted to the consideration of the identity or individuality of surra, nagana, dourine, and mal de caderas. This is an important subject from a scientific standpoint, but as an aid to the evolution of means of prevention or cure it is of little consequence. As in the case of the parasite, we have with most other writers left the subject open, but we are strongly inclined to believe them the same disease, in which case surra would be the only vernacular name allowable. There is certainly nothing in the clinical study of these diseases to differentiate them. The only real arguments in favor of their individuality are based upon morphologic differences in the parasites, and, as has already been said, these appear to us to be so slight that a positive classification can not be founded on them.

The study of prophylaxis has included the consideration of quarantine laws intended to prevent the infection or reinfection of a country, as the case may be, and of methods for the control and eradication of the disease in territories where it already has a foothold. In discussing this matter we have limited ourselves almost entirely to the consideration of means adapted for destroying the hosts and supplemented by those suitable for combating the carrying agents. It has been thought necessary to go into this subject with considerable detail, and miscellaneous conditions have been given full consideration.

Prophylactic and curative serum therapy have thus far failed to give successful results, but if recent reports from Africa are to be trusted, preventive inoculation is not wholly without promise of success.

All methods tried for the treatment of the disease have been without results of practical importance or significance.

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[Compiled and edited by Miss Mary Polk, librarian, bureau of government laboratories.]

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A REPORT ON HEMORRHAGIC SEPTICEMIA IN ANIMALS IN THE PHILIPPINE ISLANDS, BY PAUL G. WOOLLEY, M. D., AND J. W. JOBLING, M. D.

The appearance of hemorrhagic septicemia in the Philippine Islands was a serious complication of the local cattle problem. Rinderpest, which had destroyed thousands of carabaos, and which had brought agriculture nearly to a standstill, was just beginning to be controlled by vigorous work with protective sera, and cattle were being immunized in China for importation into these islands. This work had been progressing very satisfactorily, when suddenly, and without warning, hemorrhagic septicemia appeared in a herd of cattle arriving in Manila from Shanghai. At about the same time that the disease was recognized here, reports were received from Hongkong giving accounts of a virulent disease prevalent there, which very much resembled bubonic plague in human beings, and which was called "cattle plague."[a]

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[a] Since the above notes were written, the report of the Government bacteriologist at Hongkong has been received. In this there is a brief summary of the morphologic and cultural characteristics of the organisms found in the animals that died in the epidemic there. This germ grew readily on the "ordinary culture media." It was a bacillus that stained more deeply at the poles, and which did not stain by Gram's method, and which was nonmotile. Its appearance on culture media was similar to that of *B. coli.* All inoculated animals died after twenty-four to forty-eight hours, with symptoms of septicemia. From his facts Hunter concludes that he is dealing with a form of hemorrhagic septicemia. But whatever the disease may be, it is not presumably the same one that we are studying, judging from the description of the organism.

Thus far these reports have been so meager that we are unable to state whether or not the disease is endemic at that port, as it seems to be in other parts of the world, and whether or not it corresponds with the disease studied here.

That hemorrhagic septicemia existed in the Philippine Islands previous to the present epidemic can not be stated with any degree of definiteness. Since our preliminary report of the present outbreak, some native doctors have stated that they had previously seen animals dying in the same manner as the ones lately affected, but whether or not these cases were identical with ours can not be determined.

Carabaos are sometimes affected with a condition similar to heat stroke, and if one of these animals should die in such an attack, the clinical features presented by it might remarkably resemble those of the acute form of hemorrhagic septicemia. One of us had recently seen such a case, in which a carabao, lately landed from a vessel, had been driven through the town and was suffering for lack of water. It suddenly staggered and fell by the roadside, frothing slightly at the mouth, and was unable to rise for at least an hour, and not until it had been drenched frequently with water. If the animal had died in this attack, acute hemorrhagic septicemia might have been suspected and a correct diagnosis could have been made only after an autopsy. But the above-mentioned statements of the previous occurrence of hemorrhagic septicemia must be taken *cum grano salis*, for there is a proneness among many physicians and the laity here to recognize any symptom complex as the disease under discussion at the time. This tendency is well shown by the fact that pseudofarcy is taken for surra by men well acquainted with horses. It is, however, possible that hemorrhagic septicemia has been seen here before, and that the disease has thus far evaded detection by laboratory workers, even though these have a wide experience with cattle diseases.

The disease is a widespread one and has been noted in almost every quarter of the globe. The first cases were in Germany and were cited by Bollinger. Later reports of epidemics in Germany have come from Kitt, Hakoby, Buch, and others; from France, where Nocard and Leclainche have reported cases, as have also Galtier and others. Bosso, Oreste, and Armanni and others have detailed descriptions of epidemics in Italy. Poels reports cases from Holland; Jensen from Denmark; Piot from Egypt; Van Eecke, Fischer, and Hubenet from Java; Reischig, Sequens, and V. Batz from Hungary; Janson from Japan; Sanfellice, Loi, and Malato from Sardinia; Pease from British India; Carrougeau and Blin and Carré from Indo-China; Lignières from South America; and Smith, Wilson and Brimhall, Reynolds, Fennimore, and Nocard from the United States. It is easy to see how the spread may have included the Philippine Islands, if the disease is a contagious one and not endemic in that Archipelago. There is a possibility that China is not to blame for the cases recently discovered here; it may be that the disease is endemic in the Philippine Islands, and that by food or water the organisms gained access to these animals through wounds of the gastro-intestinal tract (or even without such wounds) or through wounds on the surface of the body, or possibly by way of the respiratory tract.

It is now settled beyond doubt that organisms resembling those of hemorrhagic septicemia are found in waters and soils. It has also been shown that similar ones are present on the mucous membranes of healthy animals. Moore, of the Bureau of Animal Industry, at Washington, for instance, has demonstrated that organisms resembling those of hemorrhagic septicemia and capable of producing the disease occurred in 90 per cent of the cattle, 48 per cent of the hogs, 50 per cent of the sheep, 16 per cent of the horses, 30 per cent of the dogs, and 90 per cent of the cats examined by him. Davaine, Pasteur, Gaffky, Gamaleia, S. Mayr, and Kitt have found organisms in waters, soils, sputum, and bronchial secretions, which, injected into the circulation of animals, caused septicemia which agreed with the usual disease in all its details.

Since this disease so closely resembles bubonic plague it might be supposed that it corresponds with it also in the sources and means of infection, but these points are awaiting explanation. Since the organisms occur so commonly in healthy animals it is probable that a lowering of resistance to disease, whether brought about by trauma or by abnormal conditions of environment, relatively increases the virulence of the organisms and brings about conditions from which infection and disease result. This is certainly true in the sporadic pneumonias of cattle, described by Theobald Smith, who believes that the organisms present in such conditions are secondary invaders.

The history of the present epidemic of hemorrhagic septicemia in the Philippine Islands is as follows:

A shipment of cattle arrived in Manila Bay from Shanghai on May 28, 1903, and was kept on board until June 1, when the animals were sent to the Perez estate in Paco. On the following day two of the animals were noticeably ill and were sent to the serum laboratory for observation.

Case I.—The first animal to die was very weak when first observed, but in fair physical condition otherwise. The conjunctivæ were somewhat congested, respiration was rapid and the feces normal. Temperature, 30.2° C. When taken off the truck at the laboratory it staggered a few steps and fell on its side. There were numerous bruises on the body, probably the result of a rough voyage across the China Sea. It ate food when placed near it, and also drank, although it did not, apparently, suffer from thirst. It had no cough. During the next few days it became a little brighter and somewhat stronger. On June 6 it was again weak and could not stand up, the hind legs seeming to be especially feeble. It gradually became weaker and diarrhea developed, but with no traces of blood or mucus. Death occurred on the ninth day after landing.

The post-mortem examination showed a few patches of subcutaneous œdema on the sides. There were a few small pericardial hemorrhages about the base of the heart. The lungs showed a number of subpleural nodules, which on section exposed granular areas, similar to those seen in broncho-pneumonia, in the stages of red and gray hepatization and suppuration. The suppurating areas were filled with a thick, granular, greenish yellow, sticky material.

Cultures were made from the lung abscesses in agar and blood serum. After twenty-four hours at 37° C., the agar tubes showed a growth of small, transparent, greyish, round colonies. The blood serum showed a very scanty growth of small colonies. Transfers were made from these tubes to various other media, and plates were also made. After a careful study of its morphologic and cultural characteristics, it appeared that the organism under consideration was a short bacillus with rounded ends, and nonmotile. Its measurements varied between 1 and 2 microns in length and 0.3 and 0.5 microns in thickness. The largest forms were seen in glucose media, the smallest on potato. From the animal body it showed well-marked polar staining, although this was not so distinct in organisms grown on artificial media. It was stained easily with the usual watery aniline stains, but was not stained by Gram's or Weigert's methods. The rods, as a rule, occurred singly, often in pairs, occasionally in chains of five or six individuals. The appearance of the growths on the usual culture media was in no way characteristic. The colonies on agar were small, greyish, transparent, and well circumscribed with little or no tendency to spread. On all the solid media approximately the same appearance was noticed. In gelatin no liquefaction was caused. In bouillon a granular deposit was formed on the sides and bottom of the tube. During the first few hours of growth, the whole medium was faintly clouded, but as the sediment was deposited the liquid became clear. After a few days the sediment became viscid, as could be shown by shaking the tube, when the precipitate rose, not in floccules but in threads. In Dunham's peptone solution the same general characteristics were observed as in broth, but the growth was not so abundant. Indol (cholera red) was produced rapidly, so that at the end of twenty-four to thirty-six hours the addition of pure sulphuric acid (free from nitrites) produced a well-marked pink color. No phenol could be appreciated. No gas was produced in solid media containing sugars, nor was the reaction changed. Milk remained unaffected even after ten days; no acid was produced, no coagulation was caused, and there was no reduction of litmus. Stab cultures in solid media showed nothing remarkable. The growth followed the line of inoculation closely with no tendency to spread, and extended to the bottom of the tube as a finely granular growth composed of small colonies. The surface growth was small, just surrounding the point of entrance of the needle.

Case II.—The second carabao was also taken to the serum laboratory on a truck, and on arriving there was unable to walk more than 30 feet. Its eyes were clear, the respiration quickened, and the body covered with numerous bruises. On the 4th of June it was able to walk and graze, and seemed to be in good condition. On June 14 it was again dull and weak, but still able to walk; the greatest weakness being in the hind quarters. Nevertheless, in spite of a good appetite, and in the absence of other symptoms, the animal gradually became greatly emaciated. On June 21 a swelling was noticed on the inner and outer sides of the left ankle. At this time the animal was hardly able to stand, although the appetite was still fair. The swelling on the ankle was incised by Doctor Slee and the contents evacuated. The abscess cavity was a loculated one and the incised tissue was quite œdematous. On June 25 diarrhea developed and two days later, when just about to die, the animal was killed and an autopsy done immediately.

The findings were as follows: Besides the incision over the left ankle, there were dried scars on both sides of the body and a small opening, discharging a greenish yellow pus, in the left flank near the quarter. Dissection of the left ankle showed that the abscess cavity extended around the joint without involving it, but reaching far up the leg. An opening into the abscess on the flank led into a mass of suppurating glands, which looked much like the broken-down ones of bubonic plague, save that the contents were more granular. The tissues about these suppurating areas were infiltrated with a gelatinous exudate of distinct yellow color. In the intermuscular and surrounding tissues there were more or less well-marked hemorrhages. On skinning the animal, a widespread subcutaneous gelatinous œdema was discovered with large and small hemorrhages. In the stomach walls and beneath the pericardium and the pleura, hemorrhages were present, some of which were well circumscribed and others irregular in outline. There was a very large extravasation of blood into the mediastinal portion of the parietal pleura, and another similar one along the descending aorta.

The lymph glands were generally enlarged, pale, and œdematous, but some were smaller and hemorrhagic. There were petechias in some of the œdematous glands. The lungs were, for the most part, crepitant, although there were areas in the left one which resembled the stage of red hepatization of broncho-pneumonia. The spleen was of about normal size, with no hemorrhages into its substance, but with many subcapsular ones. The liver showed nothing remarkable. The kidneys were of fair size and the perienal tissues were œdematous, and their pelves were filled with a gelatinous material. There were no hemorrhages into mesentery.

In the abscesses from the left ankle and from the hind quarters small polar-staining bacilli were found in almost pure culture. Smears from the lymph glands showed similar organisms, but the heart's blood was apparently free from them. Cultures showed an organism that corresponded with that from Case I.

Case III.—This animal, a full-grown carabao, was apparently perfectly well until one morning, when it looked stupid; its gait was clumsier than usual and its eyes appeared to be sunken. It did not care to use the mud bath, but wandered about aimlessly (the native overseer said that it was insane). On the third day weakness across the loins and in the forelegs was evident. Its appetite was still fair. On the morning of the fourth day it fell over and was unable to rise again, and died in the afternoon. Smears showed a few organisms that were polar-staining. Culture on placenta fluid showed organisms that resembled diplicocci. Culture lost in moving.

Case IV.—This animal was stupid and weak when first noticed, and as nearly as could be determined had been sick for about three hours. It kept on its feet and moved from place to place for several hours, eating occasionally. Death took place suddenly. Smears from organs showed a few polar-staining organisms. Cultures not made.

Case V.—This carabao lived about three days after the appearance of the first symptoms, the principal one of which was weakness, especially in the fore legs. At autopsy the base of the heart was œdematous, and there were scattered areas of subcutaneous œdema with a few hemorrhages.

Case VI.—Death was very sudden, occurring twenty-four hours after the beginning of the illness. Autopsy revealed œdema and blood-stained infiltrations about the inguinal and prescapular glands. The latter were much swollen and showed areas of necrosis and a few small hemorrhages in their substance. Hemorrhages varying in size were present in the inner and outer surfaces of the intestines, under the visceral and parietal pleura, under the parietal and visceral pericardium, and under the endocardium. Petechiæ were present on the surface of the liver and were especially well marked on the inner surfaces of the branches of the portal vein. A few small hemorrhages were found under the capsule of the spleen and under the surface of the diaphragm. Smears from lymph glands, liver, spleen, and lungs showed polar-staining bacilli.

Case VII.—The duration of the illness was two and one-half days, during which the animal could scarcely stand, although the appetite remained good. The almost characteristic œdemas were well marked in this case, and polar-staining baccilli were found in smears.

Case VIII.—This animal, one of the finest in the herd, was alive and well on the morning of June 7. The following morning it was found dead. The post-mortem examination showed hemorrhagic œdema under the skin along the spine, about the prescapular glands, and around the base of the heart. There were ecchymoses on the surface of the heart, under the capsule of the spleen, in the inguinal and prescapular glands, in the pancreas, in the gall bladder, and under the serous and mucous surfaces of the intestines.

Smears from heart and spleen showed polar-staining bacilli, some of which showed evidences of having been a capsule or pseudo-capsule. Blood serum from the case had no agglutinative reaction on the bacilli previously obtained from other cases.

Cases IX and *X* were calves. Their clinical histories and the details of the autopsies are wanting. All that is known is that in neither case was the spleen enlarged; that there were subcutaneous gelatinous œdema, and the usual œdema about the base of the heart in each.

Case XI.—This animal died within twenty-four hours after the appearance of the first symptoms. It was large and well nourished, and when examined was lying on the ground, the legs stiff and the head drawn back. The agonal stool was bloody. There were hemorrhages along the spine into the subcutaneous tissues, as well as on the surfaces (inner and outer) of the small intestines. The prescapular glands showed areas of hemorrhage and necrosis.

Case XIII.—This was a fairly well-nourished carabao, which had arrived from Shanghai three days previous to the appearance of illness. It was well on the evening of July 22. On the following morning it was found dead. In this case the lesions were confined to the heart and lungs. The subcutaneous gelatinous œdema seen in the other cases was absent. The lungs were not collapsed and contained air in only a few patches. The costal pleura, which was intensely inflamed and showed numerous ecchymoses, was covered with a thick stratum of fibrino-purulent exudate. The visceral pleura was in a similar condition. The mediastinum was filled with a mass of yellow gelatinous material composed of serum and fibrin. On section the lung tissue was red, in places very dark, and divided into large and small lobules by white fibrins and fibrinous bands intersecting in all directions. These bands varied from one-eighth to one-half an inch in width, and were studded with loculi containing a sero-fibrinous and fibrino-purulent material. In the pericardial cavity was a large amount of serous fluid containing floccules. Both layers of the pericardium were covered with fibrinous shreds. The serous membrane under this exudate was inflamed and dotted with ecchymoses. The auricular appendages were thickly mottled with hemorrhages.

Smears from the heart's blood, lungs, liver, and lymph glands showed a considerable number of polar-staining bacilli, and cultures showed a similar organism in uncontaminated growths.

This case followed closely the description of sporadic pneumonia as given by Theobald Smith.

Besides the cases of hemorrhagic septicæmia seen in carabaos, a native horse was found to be suffering from a malady which was caused by the same organism. In this case the chief lesions were found in the lungs, and these corresponded perfectly with those of Case I. There was also a well-marked gelatinous œdema about the base of the heart. The organism was recognized in smears and cultures, and identified with that from Case I.

In summarizing the chief clinical features of these cases we can say that there have been three fairly well differentiated types; one, intensely acute, in which the animals died within a few hours after the onset of symptoms; one less acute, in which the animal suffered chiefly from weakness in the limbs, and more especially in the hind quarters (during the course of this form of the disease the appetite was little or not at all affected); lastly, one in which the course was prolonged, accompanied by great weakness and emaciation and occasionally by suppuration. These are not distinctly defined types, for rarely does the disease affect the animals in the same way, except in the acute form, in which the course is so rapid that there is little time to observe symptoms.

The pathological types are as indefinitely defined as the clinical types. In a general way, however, there is a pulmonary type, in which the lesions resemble those of broncho-pneumonia, sometimes with abscess formation, and with or without pleuritis. Combined with these changes there may be marked changes in the interlobular tissues, with the formation of fibrous bands and with emphysema. Another type is the rapidly fatal septicæmia form, in which there are few macroscopic changes in the organs beyond incipient parenchymatous degenerations. The third type is a glandular and suppurative one which terminates in a general infection. In all these forms there have been more or less widespread hemorrhagic lesions, combined with gelatinous œdemas. This last-named condition was especially frequent about the base of the heart, and in some cases it was the only macroscopic lesion.

In but few cases have complete temperature charts been kept, because most of the animals have come from herds regarded as healthy, and have died too suddenly to allow records to be prepared. The temperature charts of Cases I and II will, however, be appended. These curves show very little except a primary rise of temperature, after which there is a fall, with the subsequent curve running either near the base line or very irregularly.

The clinical cases given above agree in many points with those described in the literature, but in many details, too, they do not. Wide variation clinically and pathologically seems to be one of the most common features of the disease caused by *B. 1. Plurisepticus.*

In Bollinger's report the cases are divided into an exanthematous and pectoral type. The former is characterized by fever, swellings of the face and neck, inflammation of the mouth and tongue, with ecchymosis under the mucous membranes, and bloody diarrhea. Such we have not seen, nor have we observed any cases resembling them. This may be because the hide of the animals that we meet with here is thick enough to prevent the œdematous swellings from becoming apparent, for certainly in the majority of cases there have been subcutaneous œdemas, some of quite considerable size. The latter type showed, principally, pulmonic lesions. We have studied three cases that followed this type, two in carabaos and one in a horse. In one carabao and in the horse the chief lesion was a broncho-pneumonia without pleuritis; in the other carabao it was a pleuro-pneumonia.

Lignières divides the cases he has seen into three classes: First, a diarrhetic one—the acute form—in which death occurs in from one to two days after the onset of the diarrhea. In this, pectoral lesions are common (i. e., pneumonia, pleurisy, etc.). The second class he calls "entèque." The course of this form is more chronic, and the animal may live for three to four weeks with more or less fever and fetid diarrhea, culminating in anæmia and death. The third or cachetic form is marked by wasting, articular localizations, and profound anæmia, followed by death.

Speaking generally, the commonest types in the literature are the exanthematous and pulmonary. Oreste and Armanni described cases in which œdemas and hemorrhages were the chief lesions. Many of Kitt's animals showed pneumonia and pleuritis, Jansen's showed phlegmonous œdemas, fibrinous pleuritis and pericarditis, and gastro-enteritis; Galtier described hepatization of the lungs, subendocardial hemorrhages, and peritonitis; Guillebeau and Hess found fibrinous pleuritis and pericarditis, hemorrhagic infarction in the lungs, and small hemorrhages in the serous membranes and in the mucous lining of the intestine; Pease observed cases in which the chief lesions were ecchymosis, widely disseminated in the bodies; Fennimore remarked inflammation of the mucous membranes of stomach and intestines, pleuritis, pericarditis, and œdema of the lungs; and Smith carefully studied and minutely described peculiar lung lesions in which interlobular changes were an important feature.

From a summary of the facts given in the literature we may conclude that the animals attacked are of all ages, the onset is usually sudden, the course is rapid, and death occurs in 85 to 98 per cent of the cases. In the less rapid forms of the disease the symptoms may be refusal of food, cessation of rumination and lactation. The initial rise of temperature may be followed by a drop to normal or subnormal. The respirations may be rapid or labored; bloody material may be discharged from the nostrils, bowels, or bladder, and noncrepitant swellings may occur on face, neck, or about the back and ankles.

From all these varying types of disease similar organisms have been isolated. In the outbreak which we have studied, the characters of the microbe have been as follows: Short bacilli with rounded ends, polar staining, occasionally encapsulated and nonmotile; nonliquefying, non-Gram staining, growing invisibly on potato, not producing gas, not coagulating milk or reducing litmus, producing indol and nitrites and not forming spores. It is an organism which corresponds closely with the bacilli of hemorrhagic septicæmia of Hueppe, and especially with that member of the group called *B. bovisepticus* (Kruse), *B. bovisepticum* (Kruse-Migula), *B. plurisepticus* (Kitt), *B. bipolare multocidum* (Kitt), *B. der buffelseuche* (Oreste-Armanni), etc. The chief differences between the present bacillus and the ones described in the literature are its indol production, which is invariable, and its invisible growth on potato, which also appears constant.

Animal experiments.[a]—The organism has been injected into guinea pigs, rabbits, monkeys, small birds, a dog, a chicken, and a calf. In all but the last three animals death has followed in from nine to thirty-six hours following subcutaneous inoculation, in from nine to twenty-four hours after intrapleural injection, in five to eighteen hours after intraperitoneal inoculation, and in five to fourteen hours after intravenous injection of virulent material. Subcutaneous injection of the filtrate collected after filtering bouillon cultures through a Pasteur-Chamberland filter caused no symptoms. Subcutaneous injection with a culture kept at 60° C. for ten minutes killed a rabbit in thirty-six hours. Intravenous injection with the same material killed in eighteen hours. In both these two last cases the organism was recovered from the heart's blood.

The lesions, in animals killed with virulent cultures, varied with the length of the disease and with the animal used. In all there was œdema and some hemorrhagic infiltration or ecchymosis at the site of inoculation. In addition to this two or three cases were noticed in which there were large collections of pus surrounded by tissues in a state of coagulation and necrosis in the immediate neighborhood of the wound of inoculation. The more resistant the animal and the more attenuated the organism (within certain limits) the greater was the tendency to suppuration.

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[a] In these experiments, Mr. Clegg, assistant bacteriologist in the biological laboratory, has given us much valuable assistance.

The protocols of the animal cases are as follows:

Rabbit 321. Inoculated subcutaneously with 0.3 c. c. of an emulsion of a 24-hour old agar growth. (Organism from Case I.) Dead in eighteen hours. Large hemorrhage at site of inoculation, and a few small ones in axillary and inguinal glands. Lungs congested, vessels of the heart distended with blood. Liver soft and showed diffused pale areas of fatty or necrotic tissue. Adrenals congested. No changes in gastro-intestinal tract. Small amount of fluid in peritoneal cavity. Smears from the liver, spleen, heart's blood, and site of inoculation showed the typical organisms which were recovered in pure culture from the blood.

Rabbit 322. Inoculated subcutaneously with 1 c. c. of a suspension of a 24-hour old agar growth of the organism obtained from Case XIII. Dead in five hours. No well-marked lesions. Some œdema about the wound of entrance. Liver and kidneys congested. No hemorrhages or necroses. Smears from heart's blood, spleen, kidney, and liver showed the typical organisms, and these were obtained in pure culture from the blood.

Rabbit 335. Inoculated intravenously with 1 c. c. of a bouillon culture of the organisms from Case I, which had been kept at 58° C. for ten minutes. Dead twenty-four hours later. Autopsy showed focal necroses in the lower lobes of both lungs, in liver, and spleen. Smears from spleen, kidney, and blood showed a few small polar-stained bacilli, which, however, were recovered in pure culture.

Monkey 256. On June 16, 1 c. c. of a bouillon culture was injected under the skin of the right side. On June 18, 1 c. c. of a culture in placenta fluid was injected into the peritoneal cavity. Death occurred six hours after the second inoculation. About the points of inoculation were areas of œdema. Surrounding the point of inoculation on the right side was also a large intermuscular abscess filled with a pale, greenish-yellow, gelatinous pus. Practically the whole side of the animal was the seat of a subcutaneous gelatinous œdema. The peritoneal cavity contained a large amount of sanguinous fluid, and the luster of the peritoneum was dulled, and it was injected. The other lesions were cloudy swelling of the parenchymatous organs. Smears from the spleen, liver, and peritoneum, and from the pus at site of inoculation showed polar-stained organisms. None seen in blood. In several leucocytes from the peritoneal cavity, polar-stained bacilli were seen. The heart, peritoneum, and liver showed pure cultures of this organism.

Monkey 297. Inoculated intra-peritoneally with 1 c. c. of a broth culture of the organism from the horse mentioned above. Death in thirty-six hours. The abdominal wall about the wound made by the needle was œdematous. The scrotum was distended and œdematous. There were well-marked subcutaneous ecchymoses and gelatinous œdema with a certain amount of purulent infiltration. Coils of intestines were adherent and there was a quantity of sanguino-purulent exudate in the peritoneal cavity. The pus extended down along the spermatic cords into the scrotum. The left testicle was much enlarged and contained some purulent and ecchymotic areas. The right testicle was small and surrounded by a purulent exudate. The intestines showed a few small hemorrhages under the serous layer. The other organs showed no marked change. Smears from the abdominal cavity, liver, spleen, subcutaneous abscess, and testicular abscesses, showed polar-stained bacilli. These were recovered in pure culture.

These case reports of animals dying spontaneously and those dying after inoculation will give some idea of the ability of the organisms to cause widely varying types of disease. It is as Reynolds has said: "For the present at least we must consider the term hemorrhagic septicæmia as quite inclusive, a sort of generic name which must cover a multitude of varying types of disease."

When we encountered the first cases of the present epidemic we feared that the outbreak might take on as dangerous proportions as it had in some of the epizootics first reported. And as time has gone on this fear has been partially realized, but we shall hold to the idea that the cases have been the direct result of trauma in many of them, and the indirect of infection with an organism present in the mouths of healthy animals.

It does seem very probable now that a pasture may become infected, and that new animals placed on such infected ground may die of the disease in one of its forms, especially if the animal is in any way predisposed to disease. For this reason it seems most unwise, in the present state of our knowledge of the disease, to move animals from place to place and so risk infecting new ground to be used by well animals.

In one of the corrals in Manila a few animals in one herd had died. Following these deaths came heavy rains so that the corral resulted in a great mudhole. Into this place a new herd of carabaos was driven after they had crossed the China Sea from Shanghai. Following the advent of these animals deaths occurred rapidly, and in all but a few of the dead the lesions of hemorrhagic septicæmia were found.

It is our own opinion that the disease was the result of the rough sea voyage, change of diet, the preliminary inoculation against rinderpest, and finally the filthy surroundings in Manila. Under these circumstances disease might be expected.

The question concerning the source of the infection by which death resulted remains to be answered. Were the organisms in the animals themselves? Were they in the mud of the corral? Neither of these questions can be answered positively as yet. We have not been able to find the bacilli in the mud. But just so long as there is any doubt the animals must be treated as though they could scatter the germs of the disease with their excreta.

Up to the present time there has been no evidence that the disease is directly contagious, although Carrougeau and Blin, Bollinger, Friedberger and Frohner, and others considered the disease, which they studied, was. On the other hand, Nocard and Leclainche think that the cases are sporadic and that the disease is enzootic, and Wilson and Brimhall and Reynolds believe that it is not contagious.

For the purpose of eliminating all or most chances of contagion, we suggest that each animal in a suspected herd should be isolated or staked out separate from the rest of the herd for at least ten days after the occurrence of the last case in the herd to which it belongs, and until any abrasions on the surface of the body have healed. (Brimhall and Wilson have suggested that skin lesions may play a part in the spread of the disease.) While the herd is under suspicion none of the animals should be allowed to use the mud baths. After an animal has died the ground upon which it has stood should be cleansed by fire or antiseptics, and if it has had access to the mud bath this should be disinfected in the most thorough way with lime or crude carbolic acid and then flushed out with water. There seems to be some difference of opinion as to whether the organism is able to live any length of time in contaminated water, but since similar ones have been found in rivers and in soils it is wiser to be on the safe side and use all precautions. Theobald Smith states that the organism is very vulnerable, and Nocard and Leclainche say that it is a facultative parasite. The result is that for the present it must be dealt with as though its resistance were great. Kitt, in Kolle and Wassermann's Handbuch, recommends that it be treated as though it were the bacillus of anthrax.

Up to the present time we have been unsuccessful in obtaining any serum or protective substance which will modify or ameliorate the course of the disease in experimental animals. Work along these lines is, however, being done and will be made the subject of a later report. Wilson and Brimhall report that they were able to produce a fairly high degree of immunity. In a book on "Les Maladies Microbiennes des Animaux," by Nocard and Leclainche, it is stated that the belief of Lignières that the organism of bovine pasteurosis can be attenuated and used as a vaccine is possible, but the details of his method are not given, and thus far we have been unable to obtain them.

NOTE.—We have been interested to hear, since the notes for this report have been prepared, that there have been epidemics of an unknown nature among chickens and swine in the provinces about Manila. The reports make it seem probable that these diseases are related to the hemorrhagic septicæmia of fowls and hogs.[a] We have received from a gentleman in Manila a chicken that had died suddenly. From this we have isolated an organism that resembles the bacillus of chicken cholera, which, when inoculated into small birds in minimal quantities gives rise to a rapidly fatal septicæmia that corresponds exactly with chicken cholera. In inoculating with this organism a needle whose tip was covered with a culture of the organism was plunged through the skin and into the subjacent muscles. The disease prevalent among swine remains to be determined.

These observations make it seem probable that chicken cholera is endemic here, and, if there is any value in the analogy, that other forms of hemorrhagic septicæmia may be.

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[a] Hog cholera and swine plague are already known to exist in these islands. See Annual Report of Superintendent Government Laboratories and Report of Commissioner of Public Health, 1902.

Literature to Accompany a Report on Hemorrhagic Septicæmia of Animals in the Philippine Islands, by Paul G. Wooley, M. D., and Jas. W. Jobling, M. D.

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REPORT ON AN ORGANISM RESEMBLING THE KOCH-WEEKS BACILLUS ISOLATED FROM TWO CASES OF A PECULIAR FORM OF HAND INFECTION, BY WILLIAM B. WHERRY, M. D.

Two cases of acute finger infection, one accidentally inoculated from the other, having certain unusual clinical characteristics, have come under our observation. The appearances and symptoms of these cases differed so much in some respects from the ordinary inflammations of the coverings of the hand that the pathogenic organisms found present were carefully investigated.

Following is the report of the bacteriological examination made in this laboratory. A complete report, including the clinical histories of the cases, will shortly be published as a bulletin from this Department.

BACTERIOLOGICAL EXAMINATION.

Coverslip preparations of the muco-purulent discharge from Doctor W.'s and Miss B.'s fingers show numerous leucocytes and mucous threads. Occasionally a cell is seen containing a number of thin influenza-like bacilli (see fig. 144). Some of these organisms lie without the cells, singly and in groups. The rods often lie side by side, or may occur end to end, in pairs or short chains. Sometimes they are so short as to appear coccoid. In the preparations from Miss B.'s finger the bacilli were much more numerous than in those from Doctor W.'s finger, often lying outside of the leucocytes in masses or groups of a hundred or more rods, or again, in short chains of eight or ten bacilli. They stain well with carbol thionin or carbol fuchsin diluted 1:10. Often they take the stain evenly, but may appear segmented, or stain more intensely at the poles, especially when carbol thionin is used. They do not retain the stain in Gram's method. When colored with hot carbol fuchsin they lose the dye when one-fourth per cent acetic acid or ordinary alcohol is applied. In size they vary from about $\frac{1}{2}$–3 μ in length by less than $\frac{1}{2}$ μ in breadth (Zeiss moc. microp.).

Throughout the acute stage of the infection this bacillus was present in considerable numbers and apparently in pure culture. When the acute symptoms had subsided it could be found only with difficulty and finally disappeared. After gangrene appeared in Miss B.'s finger nothing but the staphylococcus pyogenes albus could be isolated.

Numerous attempts at cultivating the bacillus were made and at first without success. Inoculations of the secretion upon plain agar[a] slants, agar smeared with human blood, ascitic fluid agar, and glucose agar, grown aërobically and anaërobically (pyrogallic acid method), remained sterile during ten to fourteen days' observation.

Finally, pieces of tissue removed in an aseptic manner from Miss B.'s finger were forced into the substance of a slant of ascitic fluid agar and incubated at body temperature. No growth appeared during the first three days' incubation, but on the fourth day one of the pieces of tissue was surrounded by a halo of cloudiness, which gradually increased in density and finally assumed a yellowish color, especially near the surface of the slant. Transplants upon ascitic fluid agar showed no growth in twenty-four hours, but in forty-eight hours a delicate typhoid-like, whitish growth could be seen along the line of inoculation. This gradually assumed a lemon-yellow color. Stained preparations from this growth showed small, slender rods resembling those seen in the preparations made directly from the purulent exudate. When suspended in a hanging drop of bouillon these rods were very actively motile. They lost the color when Gram's method was applied.

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[a] The "ordinary" media used were prepared according to the directions of the American committee (Reports and Papers of the American Public Health Association, 1898, XXIII, p. 60), with a reaction of 1 per cent acid to phenolphthalein. The ascitic fluid agar was kindly furnished by Mr. Lindquist, of the First Reserve Hospital Laboratory. It was prepared by mixing equal parts of fluid glucose agar and acetic serum and then sterilized by the intermittent method. For better methods of preparing human serum media, see Eyre Jour. of Path., 1900, VI, 6, and Libman, N. Y. Med. Rec., 1903, LXIII, 237.

Notwithstanding the difficulty experienced in obtaining the first culture, the bacillus adapted itself to a saprophytic existence and grew readily upon the "ordinary" media. In no instance could growth be detected with the naked eye after twenty-four hours' incubation, but it was evident in forty-eight hours. (This peculiarity persisted in 10 or 12 transplants during two months' cultivation, but after about three months of saprophytic existence the growth, though faint, is visible in twenty-four hours.)

Cultural characteristics.—On a slant of nutrient agar the growth is visible in forty-eight hours as a distinctly yellowish streak confluent below, with small, circular, isolated colonies above, and much more luxuriant than that upon ascitic fluid agar. In a stained preparation the bacilli appear thicker than when taken from ascitic fluid agar and show a considerable change in their morphology—most of them being spherical or coccoid, others ovoid and in pairs. A few appear as distinct rods. They are nonmotile when suspended in a drop of bouillon. When an isolated colony from such an agar slant or from an agar plate is transplanted upon ascitic fluid agar, the growth reverts in its appearance to the more delicate type, while the organisms all assume the thin bacillary form—actively motile when suspended in a drop of bouillion.

When plated in agar, pin-point sized colonies are visible in forty-eight hours, and in four or five days reach a diameter of ½ mm. In forty-eight hours, the superficial colonies appear, under a low-power lens, as uniformly granular disks with translucent edges. In four days coarser granulations may be seen about the central portion of the disks, and the colonies assume a chrome-yellow color. These colonies, situated between the agar and the Petri dish, spread out like the superficial colonies and have the same appearance microscopically, but are unpigmented.

In bouillon a faint, uniform cloudiness appears in forty-eight hours. In the hanging drop short nonmotile rods may be seen. In a week the fluid is densely clouded, a precipitate collects at the bottom of the tube, while a yellowish white pellicle is formed on the surface. This pellicle, if unbroken, becomes thick and wrinkled in the course of ten or twelve days. No indol is produced.

In Dunham's peptone solution a faint turbidity appears in four days. No pellicle is formed and the growth is gradually precipitated. No indol is produced.

In nutrient gelatin (20 per cent, liquified by the warm weather) growth appears as small isolated colonies floating on the surface and scattered throughout the medium. No peptonization occurs during five days' growth, at about 28° to 30° C., for the gelatin solidifies readily when placed upon ice.

In litmus milk no visible change is produced during the first four days. In a week there is slight reduction of the litmus at the bottom of the tube. In twelve days the litmus is completely reduced excepting at the surface, where it is still blue for a depth of 2 or 3 mm. No coagulation occurs.

In stab cultures, in glucose agar, and litmus lactose agar no particular changes are produced. A granular growth appears along the upper portions of the stab, while on the surface a smooth, circular, elevated growth appears. This gradually changes in color from a lemon to a chrome yellow.

In glucose bouillon, in the fermentation tube, no gas is produced, and the closed arm remains clear during twelve days' observation.

On a slant of potato the first growth appears in four days as minute lemon-yellow colonies. In eight days the colonies are confluent, of a chrome-yellow color, and present a wrinkled surface. In ten days the surface is elevated into snake-like folds. When stained from an eight-day potato culture the bacilli appear as irregularly clubbed rods. Nothing resembling spores can be stained.

Inoculation experiments.—(1) Monkey No. 260 received a subcutaneous injection in the chest of 1½ c. c. of a physiological salt solution emulsion of the purulent secretion from Miss B.'s finger. No result followed. A few days later a small piece of tissue curetted from Miss B.'s finger was placed under the skin of the chest and the wound covered with flexible collodion. Four days later a small amount of purulent secretion appeared through cracks in the collodion dressing. This contained pus cells and a few small bacilli, which could not be grown upon plain agar. In a few days the wound had healed completely.

(2) Monkey No. 261 received a subcutaneous injection in the chest of 1½ c. c. of a well-clouded emulsion of the purulent secretion from Doctor W.'s finger. Microscopical examination of the pus showed that numerous bacilli were present. In forty-eight hours a pea-sized nodule appeared at the site of injection. Two days later this had completely disappeared, and the monkey remained well during a month's observation. Then it received in the tip of the right forefinger an injection of ½ c. c. of a twenty-four hour bouillon culture of the bacillus isolated from Miss B.'s finger. Microscopically the culture showed numerous coccoid bodies and short rods. No particular change was noticed during the first two weeks' observation, but in the

course of a month the monkey's hand showed an inflammatory process, affecting the first three fingers. The tip of the forefinger was gangrenous, and the middle and ring fingers showed swollen, globular, whitish tips. Coverslip preparations showed cocci and bacilli. Many of the latter were very minute rods, losing the stain when Gram's method was applied. They could not be isolated upon ordinary agar plates, and plates made with human serum, according to the method of Pakes,[a] were rapidly overgrown by other organisms. The staphylococcus aureus and albus and some unidentified, large, rapidly-growing bacilli were present in considerable numbers. The animal was chloroformed, and at the autopsy nothing in particular was noticed, excepting swelling and congestion of the right axillary glands. Sections from the spleen, liver, and kidney appeared normal. Those from the right forefinger showed that the inflammatory process was apparently limited to the outer layers of the skin, the malphigian layer being almost wholly replaced by a mass of nuclear fragments and many cocci and bacilli. The interpapillary pegs of the epidermis showed marked canthosis—long, slender processes of epithelium running deed into the subcutaneous tissue. The subcutis showed almost no infiltration.

(3) A young rabbit, No. 269, received in the subcutaneous tissue of the left ear an injection of about $\frac{1}{8}$ c. c. of a densely clouded seven-day old boullion culture of the bacillus isolated from Miss B.'s finger. This was followed by hyperæmia at the site of the injection, but no inflammatory process resulted.

(4) A young rabbit, No. 272, received an intravenous injection of $\frac{1}{2}$ c. c. of an emulsion of the same bacillus taken from a seven-day old culture on ascitic fluid agar. It remained well during two weeks observation, when it escaped.

(5) Guinea pig No. 270 received an intraperitoneal injection of 1 c. c. of a seven-day old boullion culture of the same bacillus. It remained well during a month's observation.

Results of the agglutination test.—Blood for these tests was obtained from Doctor W.'s ear and from Miss B.'s infected finger at the time when the infectious process was in a retrogressive stage. Both specimens failed to agglutinate the bacillus in two hours at a dilution of 1:10.

There were several cases of acute contagious conjunctivitis in the hospital at the time when Doctor W.'s finger was infected. The bacilli in the coverslip preparations from the cases correspond in their morphology, size, and staining reactions with those in the preparations from Doctor W.'s and Miss B.'s fingers. They also correspond in their morphology, distribution, and staining reactions with the descriptions of the Koch-Weeks bacillus. They could not be cultivated upon the ordinary media nor upon agar smeared with human blood. As we believe the organism described above to be the Koch-Weeks bacillus itself, or a closely related "type" of this organism, it seems desirable to append a description of this bacillus and of other organisms described as resembling it.

Acute contagious conjunctivitis (otherwise known as acute or epidemic catarrhal conjuntivitis, muco-purulent conjunctivitis, or vulgarly as "pink-eye") is a highly contagious, muco-purulent inflammation of the conjunctiva, accompanied by some swelling of the lids (Weeks). The disease is self-limited, passing through an acute stage and then gradually subsiding. Recovery usually occurs in from two to three weeks. The disease is said to be especially prevalent in Egypt, but it occurs throughout the globe.

The specific cause of the disease, a small bacillus, was first seen in a case of conjunctival catarrh by Koch (1) in Egypt (1883) and cultivated, and proved to be the specific micro-organism by Weeks (2) in America (1886). Therefore the virus is usually known as the Koch-Weeks bacillus. Their work has since been confirmed by Kartulis (3) in Egypt, Morax in France, and Wildbrand, Sänger, and Stalin (4) in Germany.

The Koch-Weeks bacillus is described[b] as a minute, nonmotile rod (0.25 by 1μ), resembling the influenza bacillus or that of mouse septicæmia. In acute cases the bacilli occur in large numbers in the muco-purulent secretion, often being taken up in considerable numbers by the phagocytes. In subacute cases they may be scarce, and in the later stages of the disease they disappear entirely. They often lie in pairs, end to end, or sometimes in short chains within and outside of the pus cells of the secretion. They stain well with the ordinary dyes, but do not retain the stain when Gram's method is applied.

When transferred from the human body to artificial media, this organism is even more restricted in its conditions of growth than the influenza bacillus, as it rarely

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[a] See Eyre, loc. cit.

[b] The only literature within our reach is that in Flügge-Mikroorganismen (5) and an article by Kartulis (3).

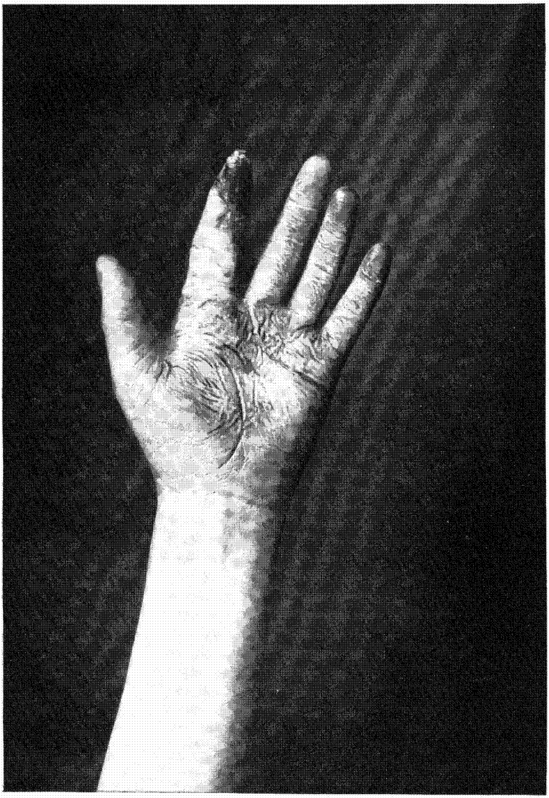

FIG. 145.—PHOTOGRAPH OF MISS B.'S HAND, TAKEN AT A TIME WHEN GANGRENE OF FOREFINGER HAD SET IN.

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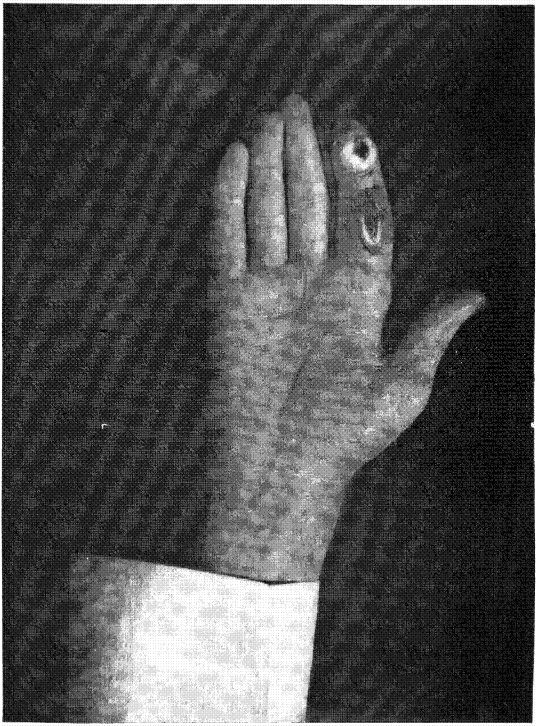

FIG. 144.—PHOTOGRAPH OF DR. W.'S HAND, TAKEN WHEN RETROGRESSIVE CHANGES HAD SET IN.

grows upon agar smeared with human blood, the best medium being human serum agar. According to Kartulis (3), "When incubated at a temperature between 28° to 30° C., the growth is first visible to the naked eye in a period of thirty to forty hours. At first it appears along the line of inoculation as small grayish-white points. Gradually the points unite into a small streak which is raised considerably above the surface of the medium. At this time the culture becomes glossy, and darker in color. The borders are uneven and well formed, and very much indented. For a long time the growth retains the described form, but it dries gradually, and then resembles the backbone of a fish. Growth upon agar-agar and gelatin is feeble. Gelatin is not liquefied. Microscopically, in a very young culture the bacillus appears somewhat plumper than those in the cells; in a very old culture they are somewhat longer and thicker. Spore formation has not been observed."

Pathogenicity.—"Transmission to the conjunctiva of animals is unsuccessful. Kartulis has obtained positive results in human beings in only one case out of six, and that with cultures 10 to 20 generations old. Weeks, on the other hand, reports several successful inoculations into human beings. His cultures, however, were not pure, but contained, besides the conjunctivitis bacillus, Xerosis bacilli (diphtheria group)" (5).

Other organisms described as resembling the Koch-Weeks bacillus.—"Another organism exceedingly like the previous, apparently differing from it only in the rather wider conditions of growth, is Müller's bacillus" (6).

"*Bacillus pseudoconjunctivitidis* (5).—Discovered by Kartulis in the conjunctival secretions in a case at Alexandria, and turned over to the author. These bacilli are nonmotile and just as small as the preceding ones, and likewise neither stain, according to Gram, nor form spores. Their cultures are rather prolific, with a canary-yellow pigmentation. The gelatin cultures liquefied first, although quite slowly, but later the liquefaction disappeared and the needle-point cultures assumed the form of a nail, with flat canary-yellow heads. On potatoes a well spread out, light-brownish deposit was formed.

"*Bacillus aeris minutissimus* (5) was obtained by Drs. Jbrahim Bey and Faud Bey in the air at the Institute of Hygiene, in Bonn. It is similar to the preceding ones, but forms a light-yellowish pigment. It is not pathogenic for animals.

"*Bacillus aureus minutissimus* (5).—Also isolated by Jbrahim and Faud on plates exposed to the air. Morphologically similar to the preceding ones, but motile; does not stain, according to Gram; does not form spores; liquefies gelatin. On potatoes it forms a luxuriant golden pollulation. It produced septicæmia in mice and abscesses in rabbits."

We are inclined to consider the organism isolated from Miss B.'s finger as identical with or as a closely related type of the Koch-Weeks bacillus. In addition to its similar morphology, the difficulty with which it was cultivated and the characteristic delay in the appearance of the growth speak for such an identity. We may have slightly overestimated its size, for ocular micrometry is a rather inaccurate method. As to the limits of accuracy in micrometry, a competent authority says: "I assume that 0.2μ is the limit of precision in microscopic measures, beyond which it is impossible to go with certainty."[a] Further, if the statement by Abbe be true (quoted from Lehmann & Neumann) that the limit of microscopic vision lies between 0.1 and 0.2μ, then obviously the diameter given by others for this bacillus—i. e., 0.25μ—is too small.

We have further found the bacillus to be actively motile when taken from a recent culture on ascitic fluid agar and suspended in bouillon. However, it is nonmotile when grown upon the ordinary media.

The ability to produce pigment, and a greater adaptibility to a saprophytic mode of existence, suggests a closer resemblance to the organism described as b. pseudoconjunctivitidis, but these faculties are variable ones in many species of micro-organisms. For instance, the variability in power of pigment production shown by the staphylococcus aureus or b. pyocyaneus may be mentioned. Again, it has often been noticed that micro-organisms isolated from a virulent form of a disease—e. g., hemorrhagic septicæmia in cattle, or cholera asiatica—do not possess a corresponding degree of pathogenicity and grow luxuriantly upon artificial media. So it is possible that in our case we happened to obtain a growth, not of the more virulent and less saprophytic type of organisms present in the tissues, but of those that had a tendency toward a saprophytic mode of existence.

As for the histological changes which this organism is able to produce, we cannot make any definite statements. It is possible that the marked canthosis occurring in the finger of monkey No. 261 may indicate the way in which the cauliflower-like verruccoid growth of tissue, occurring in the human cases, was produced.

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[a] W. A. Rogers, Proc. Am. Soc. Micrs., 1883, p. 198.

REFERENCE CITED IN THE TEXT OF REPORT OF AN ORGANISM RESEMBLING KOCH-WEEKS BACILLUS, ISOLATED FROM TWO CASES OF A PECULIAR FORM OF HAND INFECTION, BY WILLIAM B. WHERRY, M. D.

(1) S. Gaffky, Arbeiten aus dem Kaiserl. Gesundheitsammte, 3.
(2) Archives of Opthalmology, 1886, XV, No. 4; or, N. Y. Med. Rec., May 31, 1887.
(3) Cent. f. Bakt. u. Parasitenk. 1887, I, 289.
(4) Jahrbüch. d. Hamb. Staatskrankenanstalten, 3, Bd. 94.
(5) Flügge-Mikroorganismen, 1896, II, 440 and 441.
(6) Muir and Ritchie, Manual of Bacteriology, Am. Ed. 1903, 201. (Müller's article will probably be found in the Wien. Med. Wchnschr. 1897.)

THE PANAMA CANAL AND ITS RELATION TO THE INTRODUCTION OF YELLOW FEVER INTO OUR EASTERN AMERICAN POSSESSIONS, BY RICHARD P. STRONG, M. D.

The question, as Doctor Manson has fully explained, is obviously one of collossal importance to the Far East. In our American possessions—the Hawaiian Islands, Guam, and the Philippines—we shall need to be continually on our guard against the importation of cases of yellow fever or of infected *Stegomyia fasciata*. During the past year yellow fever has frequently been present in Panama, the proposed western terminus of the canal. Thus, from April 22 to May 12, 1902, 8 cases and 6 deaths were reported. From July 1, 1902, until the middle of January of this year, according to the health reports of the United States Marine-Hospital Service, there have been 133 cases and 23 deaths of yellow fever in that city.

As has long been recognized, the disease often follows the lines of commercial maritime travel. It is well known that there are frequent instances of the introduction of the malady by vessels into hitherto uninfected regions. Good examples of the conveyance of the disease by ships over short distances may be seen in the infection of the southern ports of the United States and of Mexico from the West Indies. Whether the West Indies were primarily infected from West Africa, or vice versa, must still remain uncertain. The first accredited record of yellow fever in Spain is that of 1730, when the disease was imported into Cadiz by a ship from Central America. The introduction of the malady into Brazil in 1849 occurred, it is said, through an infected vessel from New Orleans which landed at Bahia. Before this time, according to some authorities, the disease was unknown in that country. However, others assert that yellow fever was imported into Lisbon from Brazil as early as 1723, and that this was its first appearance in Europe. At any rate, since 1849 yellow fever has never been absent from Brazil. The introduction of the disease into Portugal by vessels from Brazil followed in 1850, 1851, and 1856. There occurred in St. Nazaire, in 1861, the only important epidemic of yellow fever that has ever broken out in France, and this was also due to infection from shipboard, as follows:

The ship *Anne Marie* sailed from Habana on June 13. On July 1, eighteen days after her departure from that port, two seamen fell sick, and five days afterwards died of yellow fever. The epidemic then spread throughout the crew, and 9 out of the total number of 16 were attacked by the disease. The ship entered the port of St. Nazaire twenty days after the last death, and ten days after the inception of the final case of suspicious illness. As no case of sickness had occurred on board during the last ten days of the voyage, and as all were well at the time of arrival, the vessel and crew were not quarantined. The *Anne Marie* lay near the shore, and at her side were moored two other vessels. Her crew were disbanded and the discharge of the cargo was intrusted to 17 stevedores, all of whom were in good health. Shortly after, 10 of them became sick and died of yellow fever, while 6 persons on shore who had been in contact with them also contracted the disease. In addition, yellow fever broke out on board both of the vessels which were lying near the *Anne Marie*, and from them others became secondarily infected. In short, the *Anne Marie* infected seven vessels directly or indirectly with yellow fever. In all there were 40 cases and 23 deaths.

The epidemic which occurred in Leghorn, Italy, in 1804, also owed its origin to a Spanish ship from Habana. During the voyage to Cadiz this ship had lost almost its entire crew from yellow fever. The crew was recruited at Cadiz and eventually arrived, after several stoppages, at Leghorn, where no quarantine was imposed. Two sick men were taken off the vessel and carried to an inn in the city, both of them dying a few days later. Shortly afterwards 12 other persons at the same inn were stricken with the disease. Suspicion was directed against the ship from Habana as the source of the trouble, and sanitary guards were stationed aboard, who also promptly contracted the fever. The malady spread gradually throughout the city of Leghorn. The statistics of this epidemic are very conflicting, it having been variously estimated that from 700 to 1,900 persons died of the disease. While it was not admitted to be yellow fever at the time, probably for commercial reasons, Palloni, who had seen and studied the epidemic, acknowledged seventeen years later that it had really been one of yellow fever.

There are many other instances in which epidemics of yellow fever have been carried by vessels directly from one port to another, and often over great distances. One need glance only for a moment at the map and then at the statistics of cases of yellow fever in numerous seaport towns during the past year to be again impressed by the relationship existing between commerce and yellow fever. During the past year among the seaport towns of the eastern coast of the Western Continent, Port Limon, Progreso, Vera Cruz, Tuxpan, Tampico, Rio de Janeiro, Bahia, Manaos, Pernambuco, Para, and Paramaribo, and among those on the western coast, Panama, and Guayaquil have all been frequent sufferers from this scourge. It does not seem improbable, therefore, that unless extreme precautions are taken against vessels passing from these regions and bound for ports in the Far East, infected ships, and even cases of yellow fever will be conveyed from the above-mentioned cities to Honolulu, or even directly to Guam, Hongkong, and the Philippine Islands.

I would remind you that as late as 1865 a sailing vessel arrived at Swansea from Santiago de Cuba, on board of which yellow fever broke out while in port, and caused the death of 15 persons. It is well known that it is not an uncommon occurrence for vessels to arrive in Italian ports from South America with a history of yellow fever on board during the voyage. With these examples in view does not the argument seem reasonable that the same thing might take place in Asiatic ports owing to the increased traffic between them and the endemically infected regions? The distance from Panama to Honolulu is 4,692 miles, which is about the same as that from Bahia to Naples, and less than that from Rio de Janeiro to Naples. Mail steamers from Panama should reach Honolulu in thirteen or fourteen days, and the Philippine Islands by a direct route in about twenty-eight days. Vessels, even though leaving Panama with no cases of yellow fever on board, and reaching Honolulu without a history of sickness en route, yet might obviously be most serious agents of infection to the Hawaiian Islands, for if *Stegomyia* which had recently bitten persons suffering with yellow fever were taken on board the ship at Panama (as the late Doctor Reed has shown) they would not be capable of conveying the disease until about twelve days later, which at the earliest would be one or two days before the arrival of the ship in Honolulu.[a] Stevedores sent on board at Honolulu to unload the cargo might be bitten by these insects and could later convey the disease to others in the Hawaiian Islands. The same might occur in Guam or the Philippines, for ships might also arrive at these ports with no cases of yellow fever on board, and without a history of the disease in route, and yet contain infected *Stegomyia* which, concealed in the hold or in other places unfrequented by the passengers or crew, had not had the opportunity of feeding upon susceptible individuals during the voyage. H. R. Carter has reported six such instances. On these occasions yellow fever appeared respectively on the eleventh, twelfth, thirty-eighth, sixty-fourth, and sixty-eighth days after the departure of the ship from the infected area. It has been shown that the *Stegomyia* is capable of conveying the disease at least as late as fifty-one days after biting a person suffering with the disease, and it would therefore still be dangerous for many days after the arrival of the vessel in an eastern port, whether it remained on board or escaped to land.

The question whether the *Stegomyia fasciata* could be kept alive during a voyage of such duration is easily answered in the affirmative. Reed, however, pointed out that free access to water is necessary to the existence of this mosquito and that when deprived of it it dies in from five to six days. There are many instances in which mosquitoes have been carried great distances at sea, and the *Stegomyia* is frequently found on board ships in tropical ports. Doctor Cummings, of the United States Marine Hospital Service, reported that a Spanish barque, sixty-five days out from Rio de Janeiro, arrived at the South Atlantic Quarantine Squadron with a veritable plague of mosquitoes, most of which belonged to the species *Stegomyia fasciata*. According to the captain's statement the mosquitoes had been present on board the ship during only forty-three days. In the water tanks of this vessel great quantities of the larvæ were found, showing that the insects were propagating and multiplying on board. I have cited above, at some length, two instances in which yellow fever was carried in vessels over great distances and for long periods of time. In the first instance the ship *Anne Marie* carried the infection from Havana to St. Nazaire. It will be remembered that this vessel entered the port ten days after the last case of yellow fever had appeared and that all on board at the time were well. The infection of the stevedores and others immediately following must have been due to the infected *Stegomyia* on board the vessel. The history of this epidemic has been carefully explained in this light by H. de Gousea. (Le Bulletin Médical de Paris, Oct. 12, 1901). While it may be argued that, as yellow fever has been successfully kept out of Italy since 1883, no cases having been registered on shore since that date, although cases of the disease frequently arrive in Italian ports, the question of its exclusion from our coast cities in the Far East probably will be an equally simple one. It seems likely, however, that the climatic and hygienic conditions in Europe are not as favorable to the development of this disease, and that moreover the ports I have particularly mentioned, viz, Honolulu, Guam, and those of the Philippine Islands, all lie within from 10° to 20° north latitude, while the Italian ports are almost all above 40° north.

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[a] In thirteen cases of experimental yellow fever, Reed and the army commission showed that the incubation period varied from forty-one hours to five days and seventeen hours. This agrees with the incubation period as clinically observed in a large number of cases by various observers.

Again, with a greatly increased maritime traffic between the endemic yellow fever ports and the East, the danger becomes manifold, and each ship so en route further increases the risk. Should, moreover, a case of yellow fever (or even infected *Stegomyia*) reach Manila, without quarantine, the chances would seem to be in favor of its not falling upon barren soil. Humidity and heat, which seem to be the ideal coefficients for the preservation of the disease, are always present in Philippine ports. The *Stegomyia fasciata* is found abundantly throughout these islands, and one may at any time readily obtain in a few minutes a number from any of the dwelling houses in Manila. Again, in the Philippine ports there will be no oncoming of cold weather to check the spread of the epidemic, a factor which hitherto seems to have been of most importance in the disappearance of the disease at various times in the United States. Since the *Stegomyia*, as well as the conditions favorable for its propagation and development, are to be found everywhere the year round, an epidemic once started here among a people of perhaps no marked immunity to the disease would probably end only when no further susceptible material existed.

But while it has seemed wise to emphasize the great importance of this subject to these people, and the greater risk of infection with yellow fever upon the opening of the Panama Canal, in the light of recent results the matter has not altogether a dark side. For example, Wood and Gorgas, stimulated by the work of the late Walter Reed, have recently shown us that it is possible by proper sanitation to entirely stamp out yellow fever from its natural endemic home, Habana, a place from which, as Doctor Manson, writing in 1898, has said, "The disease is never absent." Having shown that the extermination of the malady is practicable in such regions, why, then, should not the same be accomplished along the entire route of the Panama Canal? It does not seem too much to hope that this will be brought about and that before the opening of the canal there will be little danger of infection from its shores or from its terminal port.

A PRACTICABLE CHOLERA VACCINE AND ITS METHOD OF PREPARATION.[a]

BY RICHARD P. STRONG, M. D.

For the past several months I have occupied myself with the task of preparing a practicable vaccine against cholera. As it is necessary for me to interrupt my studies on this subject for a time, and as the results already obtained seem favorable, it has been thought advisable to publish a very brief account of some of the experimental work.

While apparently there is little or no reason to doubt that human vaccination against cholera with either the Perran-Haffkins or the Kolle method, when properly applied, gives rise to a good immunity, there is nevertheless little hope that either method will ever become a general one on account of the severe local reaction and the constitutional symptoms which usually follow the administration of each. Indeed, Kolle himself admits that these methods are far too severe for practical use.

In my search for a practicable vaccine I first studied the local reaction and other toxic effects produced in animals after the injection both of a very virulent cholera culture and of one which through cultivation on artificial media for a long period of time (nine years) had lost most of its virulence. The effects of the killed as well as of the living organisms were also studied with each culture. These two stems, for the sake of brevity, will be referred to in the article as "virulent" and "avirulent."

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[a] From the Institut für Infectionskrankheiten in Berlin. (Director: Geh. Med.-Rath. Prof. Dr. R. Koch.)

Some time was spent in accurately standardizing these cultures, and the minimal lethal dose for guinea pigs of 250 grams weight was carefully determined. After numerous passages of "virulent" through animals a minimal lethel dose of one-tenth of a standard dose of a twenty-four-hour agar culture was reached. Such a dose of "virulent" suspended in 1. c. c. of an 0.85 per cent solution of sodium chloride and injected intraperitoneally into a guinea pig of 250 grams weight, regularly caused death within twenty-four hours. With "avirulent," on the other hand, one and one-half of a standard dose of a twenty-four-hour agar culture injected intraperitoneally were required to produce death within this time in such an animal. The former stem, therefore, may be said to possess fifteen times the virulence of the latter. Throughout the course of the work this relation between the organisms was carefully preserved and continually tested by animal inoculation. As the virulence of cholera cultures changes in a few days on laboratory media it is necessary to make daily inoculations and always to use the same generation of the stem.

It soon became evident that the local reaction upon the tissues in animals after the subcutaneous injection of "avirulent" was much less than after one with virulent cholera spirilla. I therefore decided to determine the character of the serum which could be produced with this avirulent organism and to compare it with the one produced by the virulent germ. Accordingly, a series of six rabbits of an average weight of 1,500 grams each was inoculated intravenously, three each with one-half oese of "virulent" and three each with one-half oese "avirulent," the organism in every instance being suspended in 1 c. c. of normal saline solution. After seven days the rabbits were all killed by bleeding and the value of the serum in each case determined for agglutinative and bactericidal properties. It was then seen that the rabbits inoculated with the virulent culture always furnished better serum than those inoculated with "avirulent," but that the value of the serum from animals treated with the former in both bactericidal and agglutinative properties was in no case more than twice that of the serum furnished by animals treated with "avirulent." The technique used in these experiments was as follows:

The reactions for agglutination were performed in the test tube. One oese of the living organisms was thoroughly emulsified with 1 c. c. of an 0.85 per cent solution of sodium chloride. The diluted serum suspended in 1 c. c. of a similar saline solution was then added and the mixture placed for two hours at 37° C. In a complete agglutination the liquid overlying the precipitated bacteria should appear entirely clear.

The bactericidal reactions were performed in the abdominal cavities of guinea pigs after the well-known method of R. Pfeiffer. The dilutions of the serum were made in normal saline solutions. One c. c. of the diluted serum was then added to 1 c. c. of bouillon containing one oese of "virulent" in suspension, after which 1 c. c. of the resulting mixture was injected into the peritoneal cavity of a guinea pig, the animal thus receiving five times the fatal dose of living organisms. A fresh guinea pig was used for each reaction, which was controlled by microscopical examination of a drop of the contents of the abdominal cavity (obtained by means of a capillary tube) as well as by the inoculation of control animals without serum. The result to the animal after twenty-four hours, whether living or dead, was regarded as the final test, though the condition of the organisms in the abdominal cavity was always carefully noted.

As an outcome such as was obtained in the foregoing experiments was not entirely unexpected, but as the results were somewhat at variance with the ideas of Haffkine, and quite different from what R. Pfeiffer found upon the intravenous injection into rabbits of dead cholera spirilla of different degrees of virulence, it was determined to repeat them. Accordingly, the second series of animals was inoculated just as the first, and on the day of inoculation, as in the previous series, the virulence of the injected organisms was verified as fifteen to one. The result was practically the same, for at the end of seven days the examination of the sera showed that the virulent stem had in only one case given a serum of more than twice the bacteriocidal value of that produced by the avirulent.

In this one case the avirulent serum was one-fourth as strong.

In the experiments performed with the subcutaneous injection of the avirulent organism, in both the living and the dead state, while the local reaction, as already mentioned, was much milder than with the use of the virulent germ, there was always considerable inflammation about the point of inoculation, and it soon became evident that it would be highly desirable to do away entirely with the bacterial cells if possible. I therefore occupied myself with the problem of extracting the immunizing properties from the bacterial bodies.

After the trial of numerous methods it was found that by the autolytic digestion of the killed spirilla in aqueous solutions the cholera receptors were set free in the fluid in great abundance, and after filtration were easily demonstrable by the fact that such filtrates possessed the power to bind the cholera uni and amboceptors (agglutinines and bacteriolysines) in a cholera-immune serum, as well as by their power after injection into rabbits of giving rise to the appearance of bactericidal, agglutinative, and antitoxic substances in the blood of these animals. Such a filtrate therefore immediately recommended itself for trial as a protective inoculation. After its efficacy as a vaccine had been demonstrated by numerous animal experiments the cholera receptors were obtained in solution in large quantities after the following manner:

The surfaces of large flat-sided flasks, filled with agar, were sprayed with twenty-hour bouillon cultures of the organism and the flasks then put aside in the incubator at 37° C. for twenty hours.[a] After this period the growth was emulsified with sterile water, removed from the surface of the agar, and the emulsion placed in a sterile flask at 60° C. for two hours. The mixture was then put aside in the incubator at 37° C. for from two to five days. The best results were apparently obtained after five days of autolytic digestion, at the end of which the emulsion was filtered through a Reichel candle. The fluid thus obtained must, of course, be examined for sterility and carefully standardized before using as a vaccine.

By means of the intravenous injection into rabbits of 1 c. c. of such a filtrate (representing the amount of receptors obtained from two oese of "virulent" after two days of digestion) there was obtained at the end of seven days a serum equal in bacteriocidal and agglutinative properties to that obtained by the injection of one-half oese of the living virulent cholera organism. Following the intravenous injection of 6 c. c. (obtained from 12 oese after five days' digestion) a serum of double this strength was obtained, such that it agglutinated in dilutions of 1 to 900 and showed a bacteriocidal reaction of 1 in 24,000. Rabbits received large intravenous injections of as high as 12 c. c. of a filtrate not too concentrated and but slightly showed the effects of the inoculation. Usually there was about one degree of temperature on the day following the inoculation. If, however, the solutions of the filtrate were too concentrated, death sometimes resulted. The injection of the filtrate obtained from the digestion of the avirulent stem likewise gave rise to immunizing properties in rabbits, and the serums obtained were from one-fifth to one-twelfth as strong as those produced by the injection of corresponding amounts of the virulent filtrate. In either case the filtrate might be evaporated in a vacuum at 37° C., and when dissolved in water and injected either subcutaneously or intravenously gave rise to a good immunity, although the results obtained were not so excellent as those following the use of the filtrate before evaporation.

I have repeatedly injected from 1 to 5 c. c. of virulent vaccine filtrate subcutaneously into a large number of both guinea pigs and rabbits practically without any signs of the appearance of a local reaction. A small guinea pig inoculated intraperitoneally with 5 c. c. of virulent filtrate died after twenty-four hours, but there were no evidences of injection of the blood vessels at the point of inoculation, neither were there any signs of injection or hemorrhage in the peritoneal cavity, but only a marked œdema of the abdominal walls. However, ½ c. c. of the precipitate remaining behind on the filter, in the form of an emulsion, gave rise to the death of guinea pigs with the presence of an extensive local reaction, injection of the vessels, and corrosion of the tissues. On the other hand, the injection of 1 c. c. of virulent vaccine filtrate perfectly and regularly protected guinea pigs after one week against the injection of five times the fatal dose of cholera spirilla. As a passing example of its value as a vaccine may be mentioned an experiment in which four large guinea pigs were inoculated, two receiving $\frac{1}{15}$ oese of virulent twenty-four hour agar culture, and the other two 5 c. c. of virulent vaccine filtrate intraperitoneally. After six days all were inoculated with 2 oese of "virulent." The two which had received the vaccine filtrate lived; the other two died. From these experiments it is easy to see that we have a very efficacious form of vaccine, and apparently one which gives rise to almost no local reaction. In fact, through the kindness of Professor Wasserman, I recently received a subcutaneous injection of a quantity of such filtrate corresponding to $\frac{1}{10}$ oese "virulent," practically without the appearance of any local reaction.

Naturally, during the course of this work the question often recurred to me upon what property the difference in virulence (15 to 1) between my two stems, virulent and avirulent, depended. Without going into detail here, it may be said that it was possible to show that in a cholera-immune serum (agglutinating and bactericidal) both of rabbits and guinea pigs, the virulent organism bound from fourteen to sixteen times as many cholera amboceptors as did the avirulent one, or, in other words, the virulent germ either possessed from fourteen to sixteen times as many receptors as the avirulent one or had from fourteen to sixteen times as great an affinity for the cholera amboceptors in its haptophore group. Experiments to determine the difference between the number of receptors possessed by the killed organisms of both stems and also the difference in the number of the receptors possessed by the filtrates obtained by autolytic digestion from each will be described in a later paper.

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[a] Cultures of twenty hours' duration were always used, because it has been found that the maximum growth of cholera cultures at 37° C. is obtained within this time. After this period a rapid death of spirilla in culture media takes place.

The use of free receptors obtained by autolytic digestion and filtration as a vaccine in other diseases, as, for example, typhoid fever and dysentery, along the same lines as I have described for cholera, naturally suggests itself. However, whether autolysis will furnish as satisfactory a vaccine with the bacilli of typhoid fever and dysentery as with the spirilla of Asiatic cholera can be determined only by actual experiment. Comradi, Neiser, and Shiga have recently suggested the use of such a method for the preparation of a curative serum in typhoid fever and dysentery. As autolytic digestion does not always give constant results with all bacteria, one is not to be discouraged by a few failures in the use of this method. Its success, perhaps, largely depends upon the fermentative power of the organism and upon the number of receptors it contains. It is my intention, if possible, shortly to make use of my vaccine in the epidemic of cholera now existing in the Philippine Islands.

In regard to the preparation of a vaccine against Asiatic cholera, I wish to add that if one accepts spirilla found in water, or even in the intestines of those who have died of cholera, and which, for example, possess more than a single terminal flagellum, or those which kill pigeons, etc., as examples of the genuine *Spirillum choleræ asiaticæ*, without having very carefully tested these organisms with an undoubted cholera-immune serum in dilutions reasonably near the agglutinating limit, and, further, if one uses such organisms in the preparation of a protective vaccine, I do not believe that very satisfactory results against Asiatic cholera can be obtained. The selection of a correct spirillum for the preparation of a vaccine is obviously of the greatest importance, and should be made with particular care. Finally, it is probable that several varieties of spirilla, such as I have referred to above, and which give characteristic growths for cholera organisms on artificial media, or even stems, such as "avirulent," may be swallowed by human beings with impunity; but I am not at all convinced that the same may be performed with very virulent stems of true *Spirillum choleræ asiaticæ*. Our experience in Manila has shown us that the genuine cholera spirillum is not nearly so variable in its serum reactions, growth on artificial media, and pathogenicity as might be supposed from some of the literature on the subject.

In conclusion, I wish to express my thanks to Prof. A. Wasserman, in whose department of this institute the work was performed, for many valuable suggestions during the course of my study. Whatever benefit may come from the use of this vaccine will in greater part belong to him.

REPORT OF THE BOTANIST OF THE BUREAU OF GOVERNMENT LABORATORIES, MR. ELMER D. MERRILL, FOR THE PERIOD COMMENCING JULY 1, 1903, AND ENDING AUGUST 31, 1903.

Botanical work under the American auspices was commenced in April, 1902, in the bureau of agriculture at the time of its organization. In July of the same year, by an act of the Civil Commission, in addition to my duties as botanist in that bureau, I was also made acting botanist to the bureau of forestry; while on July 28, 1903, by act of the Civil Commission, I was transferred with all botanical work to the bureau of government laboratories, the object of this transfer being to bring the scientific work under one head as far as possible, so as to avoid duplication of libraries and equipment.

Reports on the work accomplished from July 1, 1902, to July 1, 1903, have been submitted to the chiefs of the bureaus of agriculture and forestry.

Pending the action of the Commission in the matter of the transfer I remained in the bureau of agriculture until August 1, on that date transferring all office equipment, botanical books, and herbarium to this office. This material, the property of the bureaus of agriculture and forestry, should be officially transferred to this office at the earliest possible date.

ORGANIZATION.

In the organization of the botanical laboratory the work should be planned to follow broad lines, and not be confined to any one or two fields of work, but rather be planned to cover all branches of botanical investigations. The botanical library and herbarium, the basis of all accurate work, should be built up as rapidly as possible; provision should be made for work in pathology, morphology, vegetable physiology, histology, ecology, etc., and at the same time systematic botany should not be neglected. At the present time the greatest need in the botanical investigation in the Philippines, is a thorough inquiry into the systematic botany, for much of the work in other branches, not only of botany, but also in forestry, agriculture, chemistry, and entomology is, to a greater or less extent, dependent on systematic botany. Following the plans of the botanical institutions established in the Tropics by the English and the Dutch, provision should be made for granting the facilities of this laboratory to such American and European botanists who may desire to work on a tropical flora. The leading educational institutions in America should be notified of the facilities offered by the laboratory for work in all lines of botanical investigations, and an attempt should be made to attract those botanists who desire some knowledge of the tropical flora and those candidates for advanced degrees searching for subjects or materials on which to prepare their theses. The plan of the United States Department of Agriculture, providing for the position of "scientific aids," at a nominal salary, has much to commend it, and, it is believed, would be entirely practicable here.

To logically carry out the plans of the Civil Commission regarding the botanical investigations in the Philippines, which resulted in the transfers from the bureaus of agriculture and forestry to this bureau, all botanical work should be done in this office, and other bureaus should cooperate with us in building up our working herbarium. At the present time there are three distinct bureaus in the department of the interior, all urgently in need or the services of a botanist, and the plan of the Commission to have all the botanical work done in one office is the most logical one, in order to avoid the expense of duplicating botanical books and equipment. However, it is impossible for one or two men to do all the work necessary, and it is hoped that a sufficient number of assistants will be provided.

The forestry bureau is at present in the greatest need of the services of a botanist, and during the past year the greater part of my time has been spent in the interests of that bureau. As the organization of the botanical laboratory is completed and assistants become available, a division of forest flora investigations should be established and certain assistants assigned to this most important branch. Pending the complete organization of the botanical laboratory our chief attention should be given to the work on the forest flora.

ASSISTANTS.

By understanding with the honorable, the Civil Commission, in July, 1903, measures were taken to find an assistant and two collectors for the botanical laboratory, and it is hoped these will be authorized and be able to report for duty within two or three months. In addition to these assistants, native collectors, should be employed, and provision should be made for an adequate clerical force in the office. One clerk who can operate a typewriter is urgently needed, a position of "curator" should be established, whose duties should be to prepare material for the herbarium, to oversee the poisoning and mounting of specimens, to distribute material in the herbarium, to distribute duplicates, to complete labels, etc., in order to relieve me of this routine work and give me opportunity to devote my attention to more important matters. Native assistants for poisoning and mounting specimens are essential, and this work will be greatly increased in the near future.

BOTANICAL LIBRARY.

The botanical books at present available have been purchased by the bureaus of agriculture and forestry, and an additional list has been sent to dealers from the bureau of government laboratories, so that we soon will be in a position to have a very creditable nucleus for an extended botanical library.

HERBARIUM.

At the time of the transfer of the botanical work to this bureau, the herbarium contained 5,061 mounted specimens, the property of the bureaus of agriculture and forestry. Since then there have been added 133 specimens secured by employees of the forestry bureau, 90 Philippine specimens collected by employees of the bureau of agriculture, 200 specimens received by the bureau of agriculture from the botanical garden at Calcutta, and 858 specimens received by the forestry bureau from the botanical garden at Buitenzorg, Java. The total number of specimens in the herbarium at present is 6,342.

PUBLICATIONS.

The publications prepared during the past year, while the botanical work was in the bureau of agriculture, are as follows:

Bulletin No. 4, bureau of agriculture: "Botany in the Philippines" an historical review of the botanical work accomplished on the Philippine flora.

Bulletin No. 1, bureau of forestry: "Report on investigations in Java in the year 1902." This consists of a report on my trip to the island, an enumeration of the Philippine plants identified, a report on the methods employed in investigating the forest flora of Java, and a report on the botanical garden at Buitenzorg.

Since my transfer to this office I have completed and presented for publication, as a bulletin of this bureau, two articles: The first, "New or noteworthy Philippine plants" consisting of descriptions of some new species, notes of nomenclature, etc.; the second, "The American element in the Philippine flora," consisting of an enumeration, and a discussion of the many plant species of American origin now known to grow in the Philippines.

Work on a dictionary of the native plant names, commenced some months ago, while I was in the bureau of agriculture, has been continued, and at the present time the manuscript is nearly ready for publication.

MISCELLANEOUS WORK.

During the past two months, considerable botanical work has been done for the Philippine exposition board in identifying material, correcting manuscripts referring to botany, agriculture, and forestry, and in preparing a chapter on "botany" for a publication of the exposition board, entitled "A description of the Philippines," and also a list of Philippine timber trees for the same work.

For this bureau work has been done on the identification of the gutta-percha and india-rubber producing plants found in the archipelago, and also many identifications of tan barks, dyewoods, gums, resins, etc., much of the latter work being in the interests of the forestry bureau and the exposition board.

For the forestry bureau reports on collections have been submitted as they have been received. The species have been identified so far as possible to name them from the material submitted.

THE NECESSITY FOR ESTABLISHING A BOTANICAL GARDEN OR A SIMILAR INSTITUTION.

To meet with the greatest amount of success in office and laboratory work the early establishment of that essential adjunct, a botanical or experimental garden, is most important. For systematic botanical work such an institution is essential, as it gives us an opportunity to collect material, buds, flowers, and fruits from the same plant in all stages of development, and accordingly enables us to draw up complete descriptions. In an ordinary field trip it is, in the majority of cases, impossible to collect complete material, for the reason that comparatively few plants bear flowers and ripe fruit at the same time, and on trips extending over a short period it is impossible to spare the time necessary to allow one or the other to develop. For work in morphology and embryology it is absolutely essential that the species on which work is being done be accessible to the worker, in order that he may prepare his material covering all stages of development of the plant. The laboratory work on dyes, tans, medicinal plants, gums, etc., is directly dependent on authentically named material, and this material can best be secured by cultivating a sufficient number of specimens of each species to supply material for laboratory work. Careful and long-continued investigations on gutta-percha trees, rubber trees, etc., can only be carried out where the growing trees are available, and in such a garden all the species procurable should be cultivated. Economic plants from the Tropics of the world should be cultivated, with a view to their possible introduction.

The proper location of such an institution is most important. That it should be readily accessible from Manila is essential, and yet at the same time it must be located considerably above the sea level and preferably in a hilly country where the soil is fairly rich, and where rainfall is abundant and fairly well distributed through the year; moreover, sufficient water for irrigation purposes must be available.

The station for forest investigations about to be established by the chief of the forestry bureau at Lamao River, Mount Mariveles, is admirably adapted for that purpose, but is not suitable as a botanical experimental garden on account of its inaccessibility. The present condition of the so-called botanical garden in Manila, is proof that we can not hope to establish a successful institution of this kind in the immediate vicinity of the city, and accordingly it is recommended that the region about Antipolo, province of Rizal, be thoroughly investigated, with a view to establishing an experimental garden at this place. It is believed that this location, all things considered, is the best that can be found, and, moreover, within a few months, when the railroad is completed to that point, will be readily accessible from Manila.

EXHIBIT D.

REPORT OF MR. CHARLES S. BANKS, ENTOMOLOGIST, FOR THE YEAR ENDING AUGUST 31, 1903.

I assumed the duties of this office on the 9th of December, 1902, and began at once a preparation of library and apparatus lists to be sent abroad for obtaining the material necessary for the prosecution of entomological investigations.

On the 27th of December I started for Negros, by order of the superintendent of government laboratories, to take up the investigation of insects affecting the cacao plant. Much of the material necessary for the work of collecting and studying insects was drawn from a small supply which I had brought from the United States; such other material as was obtainable in Manila, including photographic plates and certain instruments and tools for use in the plantations, was also carried with me.

My work in Negros covered a period of about twelve weeks of active field investigation and collecting of material. Through the courtesy of a Filipino friend with whom I had lived for a little more than a year, I was enabled to make my headquarters within very easy reach of his large cacao orchard, where I had every opportunity to study the trees, and the insects affecting them, under the most favorable conditions possible.

From this place as a base I was enabled to visit many of the surrounding towns to study conditions of cacao culture and the prevalence of insect pests. The following places, in addition to Nakalang, the place where I worked, were visited, viz: Hacienda Prudencia, Makakati, Las Delicias, Murcia, La Carlota, Pontavedra, Hacienda Concordia, San Carlos, Hacienda San Vicente, and Valle Hermoso.

All the work of developing photographs and the rearrangement and packing of material was done at the Hacienda Louisiana, the home of Señor Don Juan A. Araneta, to whose aid I owe much of the success of my work.

My work at Nakalang included the collection of all insect and myriapod life found in connection with the cacao, whether known to be harmful or not. In addition to this, biologic and ecologic studies were made with those insects for the study of which the season presented the most favorable opportunites.

More than one hundred species were found upon the cacao, either as injurious, beneficial, or neutral forms. Of these, only the most important have been treated in my report.

In addition to the collection of about 3,000 specimens from the cacao, a large amount of general material was gathered by myself and my helpers, and the total number of specimens thus added to the collection will be about 8,000.

The principal results of the work in Negros have been a more thorough knowledge of the forms of insects attacking the cacao and a better understanding of the best methods of preventing or combating their ravages.

The locust pest has been reported from many provinces, including Tayabas, Abra, Lepanto-Bontoc, Rizal, Capiz, Negros Occidental and Negros Oriental, Laguna, Batangas, and has probably been prevalent to a greater or less degree in every other province in the archipelago.

As yet the locust fungus can not be said to be effectual against the hordes found here. On the 6th of May I went to the province of Abra, where it was claimed that the locusts were doing great damage. A two-weeks trial with the fungus resulted negatively as far as its efficacy with swarms of locusts was concerned. Other experiments carried on by the board of health and by individuals have given practically the same results. I shall, however, take up this subject at the earliest moment and by careful experiments in breeding and a study of the anatomy, physiology, and biology of the insects determine if the fungus can not be made effective upon them, not only as individuals, but by producing an infection which will become enzootic, or at least contagious, over more than one generation. As far as Philippine locusts are concerned, nothing is yet known of the pathologic effects of the fungus. We know that in the laboratory they have died within a reasonably short time after inoculation when a certain degree of humidity was maintained, but that is all.[a]

Requests have come to me for the determinations of mosquitoes, flies, and a few other insects during the period since I began work. These requests have been complied with as far as the literature and identified material at hand would permit. Very little general classification has been attempted thus far, owing to the lack of literature, but when the large order of books which have been sent for arrives, more work along this line will be done. Already there has accumulated a large amount of material which, when properly mounted and classified, will form a nucleus for a very respectable collection. As yet the inauguration of entomological work has not become generally known in the provinces, but I have no doubt that as soon as farmers realize that they have a place where they may send material for identification they will avail themselves of the services of the entomologist for this work, and we will thereby become familiar with conditions as they exist throughout the islands.

Early in June, Mr. J. L. Webb came to this laboratory as assistant entomologist. He was designated to study the forest insects of the islands, and during his investigations collected a considerable amount of material, which will be worked up at the earliest moment. Owing to ill health he resigned his position on the last of this month to return to America, having worked a little more than two months and a half.

In the new temporary quarters of the biological laboratory facilities have been provided for the entomological work and for storing the collections until the new laboratory building is completed, where ample quarters have been appointed for the entomologist and his staff, which is to be augmented as needs require.

Many friends in Manila, a list of whom is given elsewhere, have donated useful material to the collection, but owing to pressure of other work the entomologist has had no time to give to field excursions around the city. It is hoped soon to get a representative collection of all insects found in the vicinity of Manila.

The collections planned may be divided into three classes: (*a*) Biologic collection, giving the stages and work of economic forms; (*b*) systematic collection, having as its ultimate end the classification of all insects of the Philippines; (*c*) display collection, intended for public exhibition in the new building, where a suitable place will be provided. At present most of the material is in vials and in Schmidt insect boxes made in Manila.

A list of the most important books on Philippine and general entomology will soon be added to the entomological laboratory, and a number of periodicals have been placed upon our subscription list. Among the most noteworthy are a complete set of the publications of the Entomological Society of London, Catalogues of Insects in the British Museum, Insect Life Complete, Fauna of British India, Coccidæ of Ceylon, Rhopalocera Nihonica, Rhopalocera Malayana, Hemiptera Insularum Philippinarum. It is hoped to build up an entomological library which will not be surpassed in the East as an aid to entomological students of this part of the world. So far the entomologist has depended almost entirely upon his private library for data and the classification of material brought in.

The insect fauna of these islands is closely related to that of Java, Australia, Borneo, Sumatra, Celebes, and, possibly in some orders, to India and eastern Asia.

As comparatively little work has thus far been done on Philippine entomology there is open for this department a new and virgin field, but the time will eventually come when material will have to be taken to Singapore, Java, or Europe for identification because of the impossibility of identifying a great deal of it without access to types.

The advisability of giving serious attention to the offer of Mr. Georg Semper, of Altona, Germany, to sell his fine collection of Lepidoptera of the Philippines, together with his author's copy of his book in thirteen volumes on the butterflies and moths of the Philippines, is here urged most earnestly because of the great value which such a collection would have, containing as it does 1,400 distinct species, of which 340 are types. As this collection is of inestimable value to entomologists here, it should find a permanent place in a museum of the Philippine Islands instead of in Europe.

The laboratory insectary is yet in its infancy, but when permanent quarters are secured the rearing of economic forms of insects will be given considerable attention and proper facilities will be planned for rearing plants and the insects which infest them.

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[a] Results from the fungus this year are much less satisfactory than those obtained during the preceding one. The reason for this it is difficult to give at present, as even new fungus obtained from Africa did not behave differently. The weather conditions apparently have much to do with the results.

The entomologist is at present working upon a bibliography of Philippine entomology and that of the adjacent countries, with a view to aiding those who wish to refer to any special subject treated by writers on oriental entomology. He is also preparing an index to C. Stäl's valuable work, "Hemiptera Insularum Philippinarum," the purpose of which is to render this work more useful and accessible to investigators.

In planning the work for the coming year, it is proposed to give some attention to the flies and mosquitoes of Manila and vicinity, with a view to determining their relation to disease both of man and animals. It is also planned to inaugurate a system of field observers in the various provinces, enlisting therein the cooperation of the American school teachers, hacienderos, and others interested in the subject of agriculture in the Philippines.

Data are being collected for a bulletin on household insects and those injurious to commercial products in the Philippines.

The entomologist has been requested by the Philippine exposition board for the St. Louis Exposition, through the chief of the bureau of government laboratories, to prepare an exhibit for the Louisiana Purchase Exposition at St. Louis in 1904, and steps have already been taken for its preparation. Cases and all necessary material will be supplied by the board, but in order to carry this work to a successful termination it will be necessary to enlist the aid of collectors in all parts of the archipelago by paying for the material furnished by them.

The entomologist wishes to acknowledge his obligations to Dr. L. O. Howard, United States entomologist at Washington; Prof. J. H. Comstock, of Cornell; Mr. Charles P. Lounsbury, Government entomologist, of the Cape of Good Hope; Dr. A. D. Hopkins, of the United States Department of Agriculture; Dr. James Fletcher, Dominion entomologist of Canada, and Mr. C. P. Gillette, entomologist of the Colorado Experiment Station, for their kind offers to identify material from the Philippines.

Insects received December 9, 1902, to August 27, 1903.

	Specimens.	Species.
Sr. Juan A. Araneta, Maao, Negros Occidental:		
Lepidoptera (224 larvæ, 12 pupæ, *Noctua*)	35	25
Hymenoptera	3	3
Coleoptera	2	2
Hemiptera	75	2
Diptera	4	3
Odonata	1	1
Orthoptera	5	1
Frank J. Dunleavy, Cotabato, Mindanao:		
Coleoptera	8	6
Orthoptera	3	2
Chilognatha	1	1
Arachnida	1	1
Vermes	1	1
J. J. Eaton, Manila:		
Lepidoptera	3	3
Orthoptera	4	3
Hemiptera	5	3
Thysanura	3	1
Coleoptera	7	3
Hymenoptera	2	2
Isoptera	15	1
Arachnida	2	2
Sr. Manuel Gaspar, Manila: *Bruchus fabæ* (in white beans)	180	....
Sra. R. de Gaspar, Manila: Hemiptera Coccidæ (several specimens on rose).		
Juan De Guzman, Manila:		
Lepidoptera	16	12
Hemiptera Coccidæ	2	2
Coleoptera	9	1
Odonata	2	2
Heteroptera	59	1
Hymenoptera	1	1
A. R. Hager, Manila: Hemiptera	1	1
C. E. Kelbaugh, Manila: Lepidoptera (larvæ)	1	1
E. L. Munson, Cavite: Diptera, *Culex fatigans* (many specimens).		
Governor W. F. Pack, Sablaan, Benguet: Coleoptera, *Epicauta* (on potato)	28	....
Miss Mary Polk, Manila: Lepidoptera	1	1
G. E. Sanford, Manila: Diptera	1	1
Dr. P. L. Sherman, Mindanao: Arachnida, Tarantula	1	1
P. L. Stangl, Manila:		
Lepidoptera	7	3
Orthoptera	....	....
Hemiptera	180	6
Coleoptera	19	13

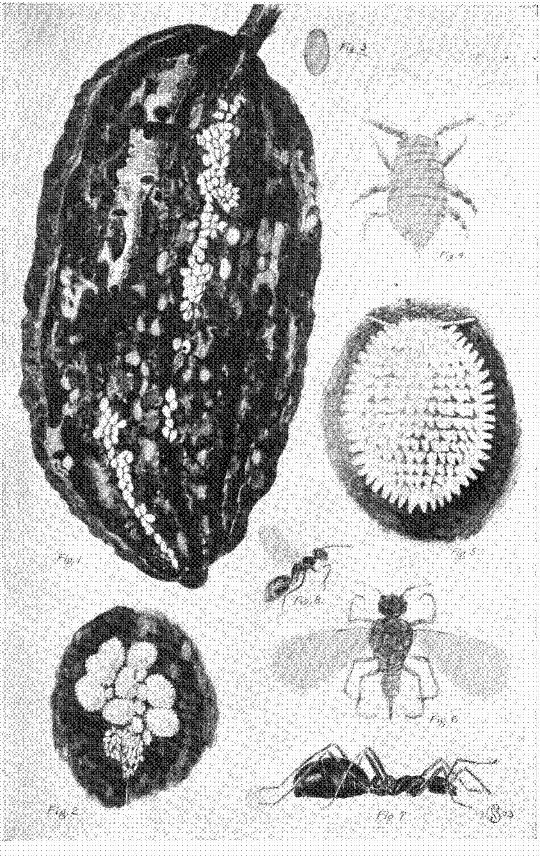

PLATE I.

Fig. 1, Cacao pod, showing mealy bug (natural size) and the attendant ants and sheds built by same; fig. 2, female mealy bug and young, slightly enlarged; fig. 3, egg about to hatch, very much enlarged; fig. 4, young insect just hatched, showing filamentous mouth parts; fig. 5, female mealy bug, very much enlarged; fig. 6, male mealy bug, very much enlarged; fig. 7, species of ant which attends mealy bugs, enlarged; fig. 8, hymenopterous parasite of mealy bug, greatly enlarged.

Drawn from nature by Charles S. Banks, 1903.

Insects received December 9, 1902, to August 27, 1903—Continued.

	Specimens.	Species.
P. L. Stangl, Manila—Continued.		
Hymenoptera	3	3
Scorpiona	1	1
Chilognatha	1	1
Isoptera	Several.	1
Acarina	1	1
Wm. B. Wherry, Manila:		
Coleoptera, *Lasioderma serricorme* (in tobacco)	3	....
Diptera, *Stegomyia fasciata* (on clothing)	7	....
Diptera, Muscidæ, all stages in culture media	....	....
F. H. Willyoung, Manila, Orthoptera	1	1
P. G. Woolley, Manila:		
Hymenoptera, Sphecidæ	1	....
Hemiptera	50	1
Lepidoptera	1	1

A PRELIMINARY REPORT ON INSECTS OF THE CACAO, PREPARED ESPECIALLY FOR THE BENEFIT OF FARMERS. BY CHARLES S. BANKS.

Up to the present time, so far as search has revealed, very little has been published upon the subject of economic entomology in the Philippine Islands. In the several admirable works on the entomology of the Archipelago we find not only that the economic side has been entirely neglected, but also that the same thing is true from the biologic standpoint. The only attempts made in the past have been to determine the names of specimens, in most cases collected by one man and classified by others. For even the most common species of insects few or no data are given regarding their habits, life, history, or relative abundance at certain periods of the year or in stated localities.

In preparing this brief preliminary report on the insects of the cacao I realize that I am but hinting at some of the more important pests that have been encountered during a comparatively short period of the year, so that all the conditions as they would occur consecutively during the course of twelve months, and undoubtedly changing slightly with each succeeding year, are not now noted, nor are all the subjects mentioned treated exhaustively, the object being at the present time only to set forth as clearly as possible some of the most common and more destructive insects, with practical suggestions for the prevention or treatment of their ravages. At the same time it is proposed to mention a few of those insects which, because of their predatory habits in feeding upon the injurious forms, should be considered as beneficial to the farmer.

Perhaps one of the most valuable crops produced in the Philippine Islands in proportion to the quantity raised is the cacao bean, the product of a tree of the family Sterculiaceæ and botanically known as *Theobroma cacao.* The tree averages from 4 to 12 meters in height, and, as grown in these islands, usually assumes a somewhat oval form in its mode of branching, like the pear tree of the United States.

Like nearly all other plants, when brought into cultivation, it is subject to many diseases and the attacks of a large number of insects. This is more or less true in all parts of the world where it is grown—in Venezuela, Trinidad, Java, and particularly, it would seem, in the Philippines.

In this bulletin some of the injurious forms of insects will be mentioned, together with what has been learned of their life histories up to the present time.

As it is very necessary to know the most susceptible stage of an insect's life in order to know what is the most effective remedy to apply to it, we can readily see the necessity for becoming familiar with its life history.

It is hoped that further observations will enable the writer to treat the subject more exhaustively at a future time.

In suggesting remedies those are given which have been found most effectual for similar pests in the United States, but the effort has been made to so modify them as to make them fit local conditions.

For convenience, the subject has been divided according to the part of the plant attacked. Thus, beginning with the roots, we will, in order, discuss the insects of every part of the tree, giving their habits and mentioning the best means to be used against them.

INSECTS ATTACKING ROOTS.

The principal insects at present known to attack the roots are a species of large, black, stinging ant, a species of *Cicada*, and a grub of a beetle belonging to the genus *Anomala*, but not yet identified.

The ants are black and are characterized by the ability to inflict a very severe sting. The abdomen is constricted between the first and second segments, the first segment having two backward-pointing spines on the upper part. The head, thorax, and first and second abdominal segments are beautifully corrugated. The legs and antennæ or feelers are very long. The light-brown cocoons, made of a silk paper, are usually very abundant in the nests, which are located at the base of the tree among the larger roots. Within these cocoons may be found the white grubs, which are shaped very much like a long-necked gourd, the head being at the smaller end. (See fig. 146*c*.) The larvæ or grubs, before spinning their cocoon, and the eggs are simply deposited by the workers in any convenient part of the nest. The adults are the only injurious forms of these insects. They gnaw the bark from the large roots, thus inviting decay, and making an opening for the entrance of the insidious white ant, another very serious enemy of the cacao, belonging to the genus *Termes*. This insect is called anay in Visayan and Tagalog, and is probably the most serious insect pest in the Philippines, destroying, as it does, nearly every conceivable class of material except articles made of metal. It has hitherto been supposed to attack only woods which had been previously cut, but in the work of investigation of cacao insects, it has been conclusively proven that they also attack the living tree, at least in the case of the cacao. (See fig. 147.)

In the United States the members of the genus *Cicada* are restricted to not more than five species. In the Philippines there are several, some being large and black and others gray, while still another species is of a very light-yellowish green. A singular thing about the individuals of the genus is that the males give forth a strident noise, produced by means of two drum-like organs on the lower side of the first segment of the abdomen. Unlike the members of this genus in America and Europe, which generally "sing" in the hottest days of summer, the individuals found in the Philippines almost invariably reserve their serenade till the falling of darkness, when their strident notes may be heard on every hand, especially near wooded lands.

All observations thus far made upon this interesting insect would lead me to infer that the habits and life history are the same in the Philippine Islands as in other parts of the world, particularly as in the case of the dog-day cicada in the United States.

Here the species may be found at all times, and the insects are so common as to be used as playthings by the native children, who capture them to make them "sing." In Visayan they are called "ceriritan" and in Tagalog "culiclic."

The adult of the species which attacks the cacao tree measures 42 mm. to the tip of the wings, which project 13 mm. beyond the tip of the abdomen. The body is robust, somewhat conical, and is composed of a series of very regular segments, which may be more easily distinguished on the abdomen than on the thorax. (See fig. 148.) The insect has four very beautifully marked transparent wings, the fore ones being much larger than the hind. The venation is shown in fig. 149.

When at rest the insect's wings are laid over the abdomen, roof like. The cicada has a swift, but erratic flight. This is due to the lack of coordination between the wing muscles of the opposite sides of the body. By holding the insect between the thumb and the fore finger, so that the wings are free to move, it will be seen that the opposite pairs move alternately.

The insects of this genus pass through a very remarkable series of changes from the egg to the adult stage. The total duration of the metamorphosis has not yet been determined, but it is safe to estimate that in this region the time occupied is not less than eighteen months. In America, one species nearly related to this, lives from thirteen to seventeen years in the ground before reaching maturity, while another completes its transformation in two years.

The female cicada is provided with a very peculiar ovipositor or egg-laying apparatus (fig. 150), by means of which she slits the twigs of young branches of the cacao. Inasmuch as the wood of the cacao is comparatively soft, she finds no great difficulty in placing her eggs in branches which are larger than those ordinarily found with cicada eggs in the United States. Within from four to six weeks from the time the eggs are laid, the young hatch. They are tiny white creatures which resemble very much the full-grown nymph, except in size. Their forefeet are adapted for digging in the ground, and they, dropping from the twigs, begin immediately to burrow down to the tender rootlets of the plant, where they settle and insert their beaks for sucking the juices of the roots. Fig. 151*a* shows the nearly full-grown nymph and fig. 152 shows its forefoot. The larva or nymph forms a dirt cell around the spot where it decides to remain. This it does with its forefeet, using them as a mole would and packing the earth at the rear and above it with its other legs. Thus is made a subterranean cavity where this little enemy of the roots of the cacao may live and feed.

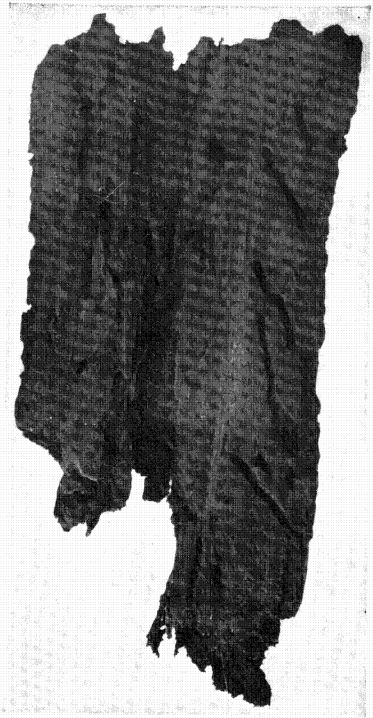

FIG. 147.

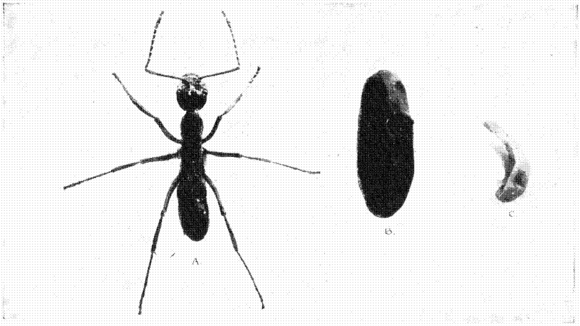

FIG. 146 C.

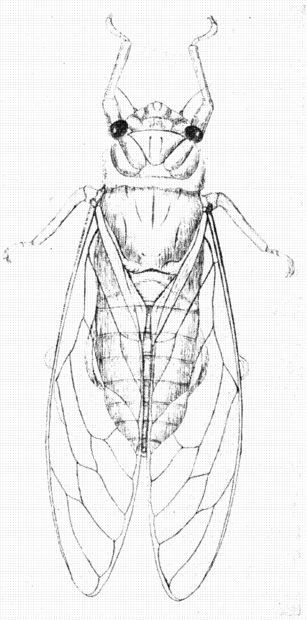

FIG. 148

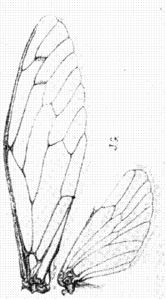

FIG. 149.

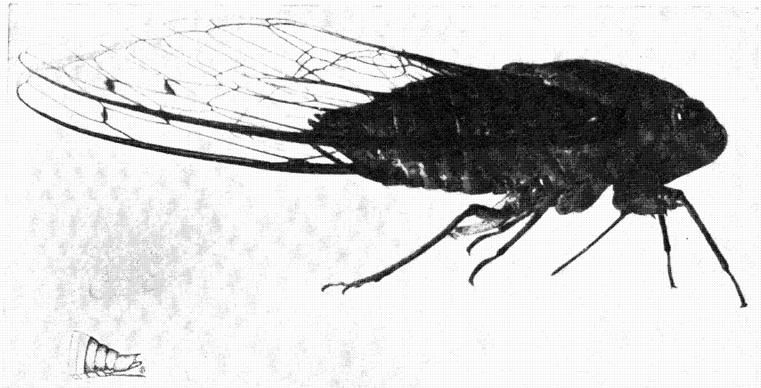

FIG. 150 (ORIGINAL).

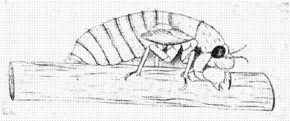

FIG. 151 (ORIGINAL).

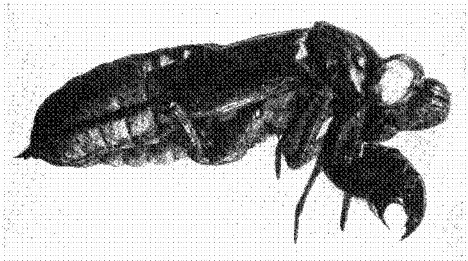

FIG. 151 *a*.

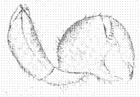

FIG. 152 (ORIGINAL).

The mouth of the insect is of the sucking class, that is, the various parts are modified to form a lancet for piercing the epidermis of the plant upon which it feeds, and a tube-like structure through which the sap is drawn up into the mouth cavity, whence it is conveyed to the stomach.

When very young the larvæ may be found not more than 10 or 12 cm. below the surface of the ground, but as they grow larger they gradually work their way downward. In some cacao trees they have been found as deep as 80 cm. below the surface, clinging tenaciously to the roots by their beaks and their legs. They are not at all able to defend themselves, nor to escape from any kind of enemy which might come upon them.

These insects do not change their form to a very marked degree in passing from the young larvæ to the pupa and the adult stages, as do butterflies, beetles, and flies. Just previous, however, to their assuming the adult form, there appear tiny wing pads on the sides, and within these are the wings in embryo. These pads appear in the second molt previous to the adult stage. (See fig. 151, which shows the wing pads lapping back upon the abdomen.)

When the insect is ready to assume its final or winged form it comes up out of the ground, leaving a tunnel behind, which may often be found when digging out trees. These tunnels are sometimes partitioned off and used as a nest by a certain species of small tarantula, which will be mentioned below.

Upon reaching the surface of the ground, the pupa of the cicada climbs to some convenient place, usually the trunk of the cacao tree or the small scions which spring up around the parent tree, and there it clings, awaiting the final change, which consists in the bursting of the pupal skin and the emerging of the adult insect. This takes place as follows: The skin of the pupa splits longitudinally on the back, from between the eyes to the posterior edge of the thorax. The insect within this shell begins a forward wriggling motion and soon the head is free from the casing. The forelegs, which in the larval and pupal stages are much shortened hooked claws, come forth from the pupal case, long, slender and fitted for walking instead of digging. The insect grasps some projecting point upon the bark where it is resting with these yet feeble claws, and thus is aided in his exit. The second pair of legs soon come forth; then the wings, which are doubled up very much and are very soft, are drawn out from the shell. At this stage the animal rests a while, apparently nearly exhausted. When it has thus rested the insect makes its final attempt and the hind legs are withdrawn. It now simply remains upon the tree, and the doubled and delicate wings begin to expand until they have reached the tip of the abdomen. This expansion continues till they have reached their full length. They are now very thin, of a beautiful translucence and very soft, so that the least breeze causes their fluttering. The body of the insect is also very soft and may be easily crushed. It is of a very pale, pinkish color, but soon turns gray (evidently owing to the action of the sunlight), all the characteristic markings coming out upon its surface. Within an hour, seldom less, the insect begins to move its wings as if testing them, and now the slightest movement on the part of the observer will cause it to quickly take wing, giving a short clicking sound as it flies away. If the insect be a male, it at once makes its characteristic "creet," a noise familiar to all, as it starts to fly. If it be a female, it remains in silence. It is not definitely known how long a period elapses from the emergence of the insect from the ground, until it mates and begins the work of laying its eggs. Further observations will be necessary to determine this.

The principal injury to the cacao from these insects consists in the lacerating of the young wood by the females in placing their eggs and in the damage done by the larvæ and pupæ to the tender rootlets. The former not only debilitates the tree from the mechanical injury, but also opens a path by which other injurious insects may enter the tree to do their damage. This is no inconsiderable feature of their harm, especially when they attack the larger twigs and stems, because it is more frequently upon the larger stems that *Scolytids*, *Cerambycids*, and other beetles do their work.

When 50 or more of the larvæ attack the young roots and rootlets, the principal food-getting organs of the tree, they not only use up the moisture which the roots have already taken up, but they likewise so mutilate and debilitate the latter as to impair the functions of moisture gathering. Of the several cacao trees which the writer dug up none were more than 5 m. high, and in no case did their roots extend more than 95 cm. below the ground surface, and as the pupæ of cicada were found as low as 80 cm. it can be readily seen that they command practically the whole of the root area.

In the matter of combating these insects several methods suggest themselves. As it is practically impossible in a large plantation to use preventive measures entirely, those means which also look to the extermination of the already established pests must be used.

The pupæ, when emerging from their ground retreats, are entirely helpless, and they, as well as the newly transformed adults, are easily captured upon the daily visits to all the trees by the watchman and workers in charge. This could very easily be done by children, who seem particularly expert in capturing the insects, which they like to make "sing." Even the full-fledged adults of several days may be captured upon the trees at dusk, when the males begin their concerts and the females are close by to listen. Occasionally during midday the insects may be caught upon the tree trunks, but are more wary and harder to capture.

Certain species of birds are known to be enemies of the cicada, at least in the island of Negros. Repeatedly, the writer, when in the cacao plantations, has heard the uneasy "creet" of the cicada, and following with his eye the direction of the sound, has seen a bird carrying of the insect. The species could not be ascertained, but from its general size and form it undoubtedly belonged to the shrikes or *Laniidæ*. This should lead the grower to carefully protect all birds which have the inclination to visit or live in the plantations of cacao, as being beneficial, not only in the destruction of the cicadas, but also in ridding the trees of other injurious insects like scale insects, mealy bugs, and caterpillars of various species.

If the insects are captured upon emerging they will have no opportunity to lay their eggs, but as this can not be done in all cases, a close daily survey of the trees at the time when the cicades are beginning to be numerous, will reveal the work which they do on the twigs. The characteristic appearance of the twigs after eggs have been deposited in them is shown in fig. 153. It was claimed a number of years ago that the cicada only deposits her eggs in dead twigs, but observation has since proven that this is not the case, she invariably choosing live wood for this purpose. The short time during which the eggs remain in the slit would not be sufficient for the growth to crush them, and moreover, the growth of a twig which has been lacerated by the ovipositor of the cicada is away from the wound, causing the latter to gape within a year from its laceration, as shown in fig. 154. If these twigs are carefully removed by means of a very sharp knife, and if they are afterwards destroyed by burning, while the eggs are yet unhatched, much can be done to lesson the number of cicadas attacking the trees.

If a twig into which eggs have been newly laid be examined by cutting it open longitudinally, the white eggs will be found arranged very regularly in the cavities which have been made to receive them. If the eggs have recently hatched, their transparent and shriveled shells will be all that can be found. After a few days these shells will have disappeared, being eaten by the numerous ants which constantly swarm on all parts of the tree. It may be that occasionally the eggs are found by the little red ants and eaten before they are hatched, but as the fibers of wood left by the boring of the female cicada pretty effectually close the cavities, this is not probable.

During the months from January to April, 1903, all sizes of larvæ and the pupæ were found when cacao trees were dug out. During this same period the adults were fairly abundant, as were the cast skins of the pupæ on the trees. It is therefore probable the period of greater abundance of the adults is during the latter part of the year, probably in October and November.

The question of the killing of larvæ after they have once entered the ground is a most difficult and serious one. There are few substances which have sufficient penetrating power to enter the soil and be effectual against the larvæ without endangering the young roots of the trees. Probably one of the most useful of these is carbon bisulphide, an extremely volatile transparent liquid resembling highly refined petroleum, but having, when not pure, an extremely disagreeable odor. It is highly inflammable and heavier than the air, and therefore sinks readily into holes or crevices in the ground. Its extreme inflammability renders great precaution necessary when handling it. It must not be kept in houses where lights are used, nor must it be left in large quantities in bright sunlight, and the vessel used to contain it must be capable of being sealed. The fumes of this chemical, while not actively poisonous when breathed by human beings in limited quantities, are extremely disagreeable and are productive of headaches. If inhaled for a moderate length of time they suffocate. The substance should be handled only by those who are thoroughly acquainted beforehand with its properties, and then only by those who can be trusted to carry out instructions concerning its use. It should be kept where it can not be reached by children, and should be labeled "poison." Glass-stoppered bottles, or tin cans having best quality cork stoppers are the best receptacles for carbon bisulphide.

It is possible that gasoline or naphtha would in a measure serve the same purpose as carbon bisulphide, but no experiments have yet been made to verify this supposition. Neither of the liquids would have the advantage of cheapness over carbon bisulphide.

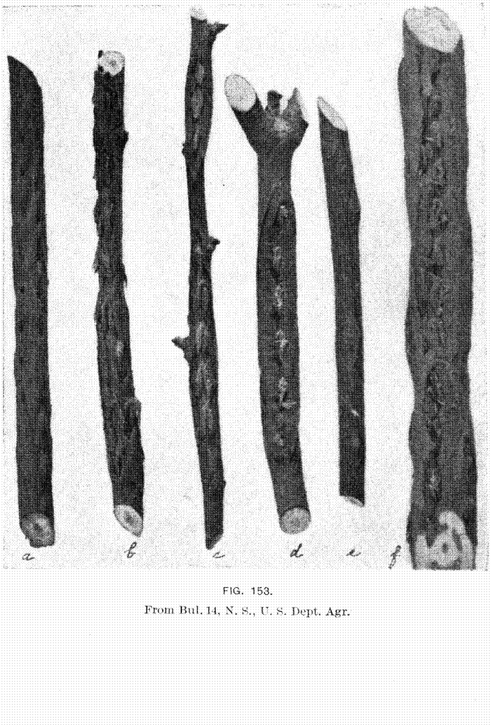

FIG. 153.

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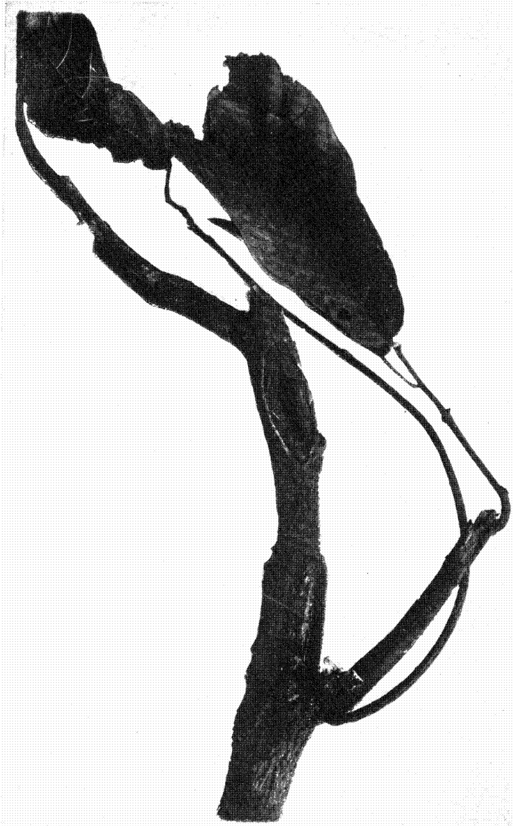


FIG. 154.

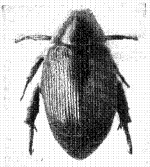


FIG. 155.

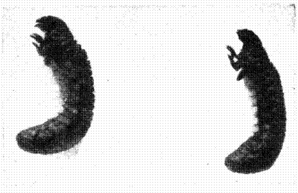


FIG. 156.

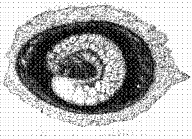


FIG. 157.

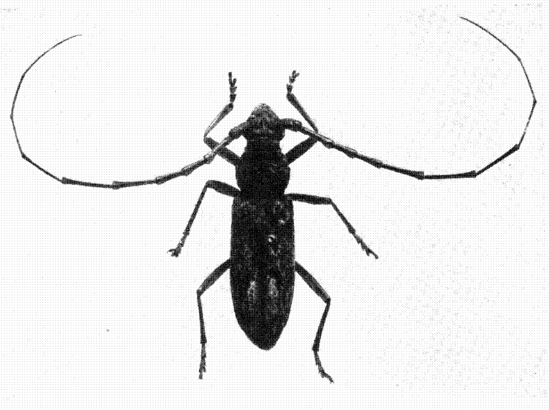


FIG. 158.

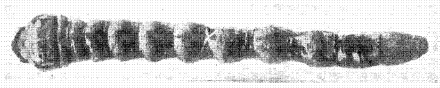
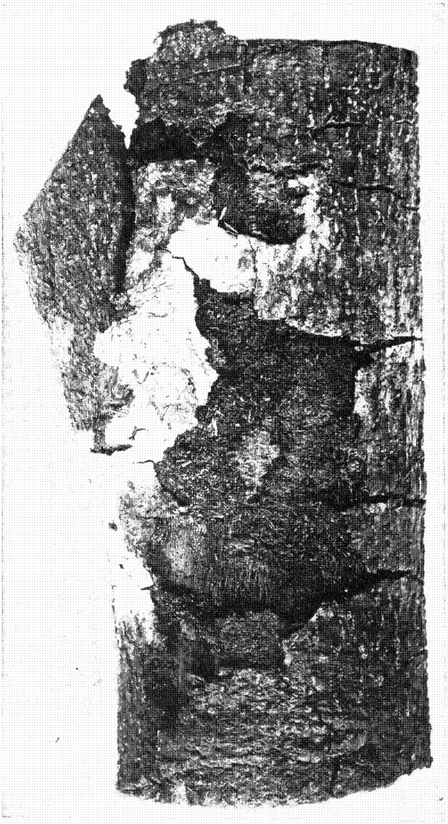


FIG. 159.



BLOTCH CAVITIES PRODUCED BY BORER, SHOWN AT FIG. 158.

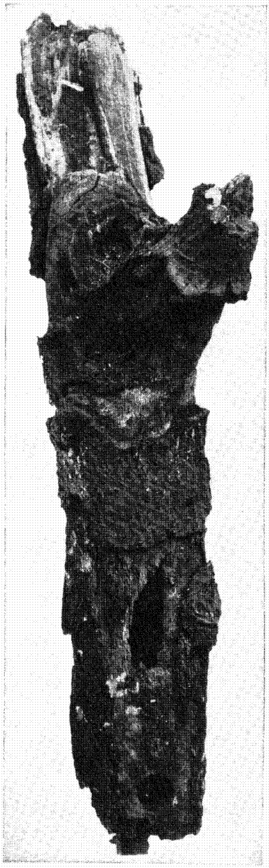


FIG. 160.

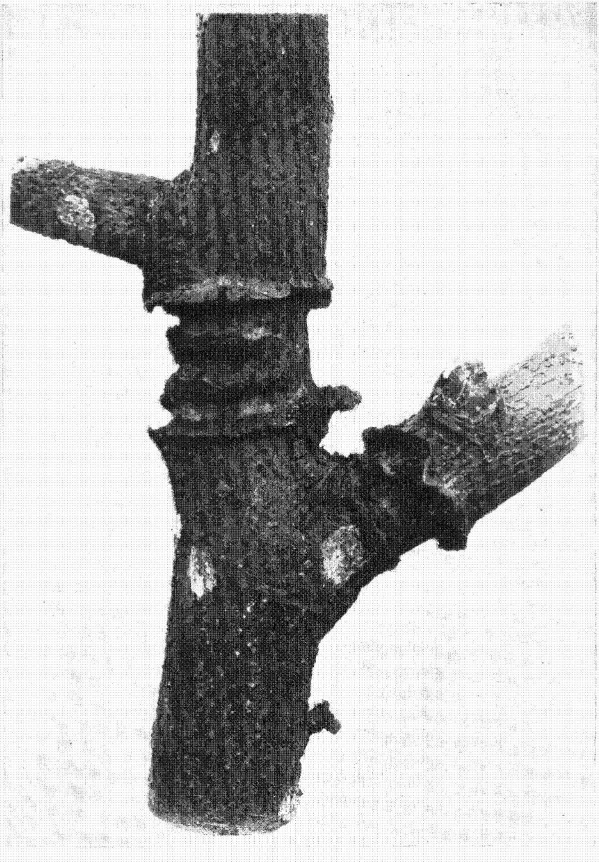


FIG. 161.

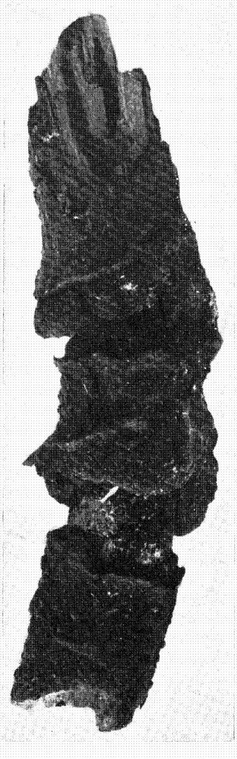


FIG. 162.

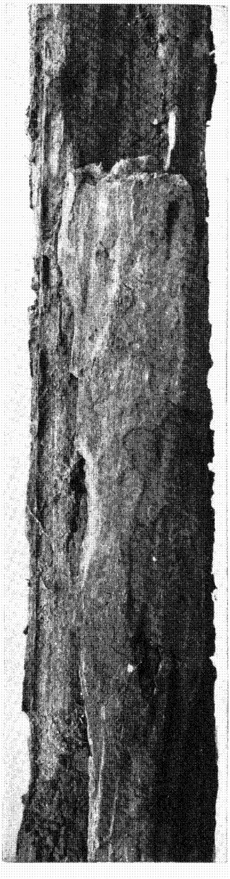


FIG. 163.

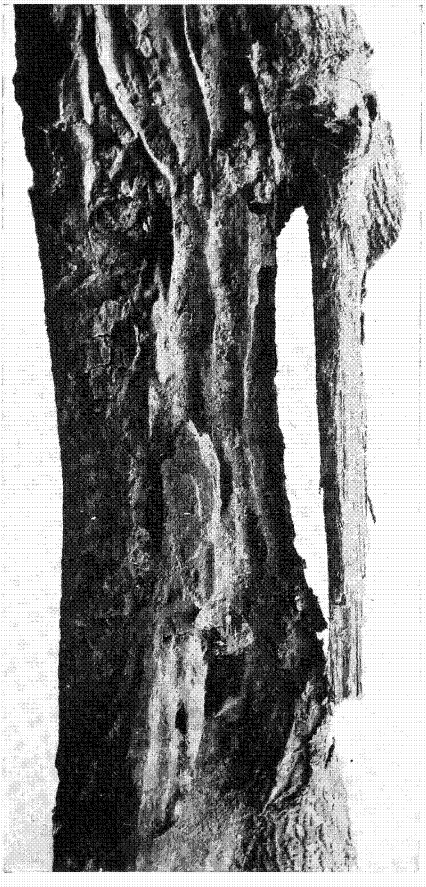


FIG. 163.

At present the price of this chemical in the Philippines is such that the general use of it as an insecticide is almost out of the question. In the United States, when bought in large quantities, it may be had for about 15 cents per pound. By the single pound it costs about 25 cents gold. In the drug stores of Manila it may be bought at 75 cents gold per pound, or 55 cents gold in quantities of from 50 to 100 pounds. It is hoped that with this, as with other important insecticides, some plan may be devised to enable the farmer here to procure them at a lower cost.

The most effective method for the application of bisulphide to trees for the killing of insects attacking the roots, and the one which is least dangerous to the tree, is as follows: The trees may be treated successively by one or several men. An instrument should be used by which a hole 50 or 60 cm. deep and 2 cm. in diameter may be bored into the earth, about half a meter from the crown of the tree. There should be three of these holes equidistant around each tree and into each should be poured not more than 25 c. c. of the carbon bisulphide. The hole, after introducing the liquid, should be immediately stopped up with wet earth or thick wet cloths, and left in this condition for several hours. The cloths can then be taken away or the ground raked or leveled if earth only has been used. These measures can be tried at any time, but preferably just after a period when a large number of twigs of the trees have been found lacerated by the female cicadas, as in all probability the eggs will have been but recently hatched and the larvæ therefore but a short distance below the ground.

When anay or ants are found working below the crown of the tree, similar measures for their extermination may be employed. A dampened canvas or other air-tight cloth may be placed around the base of the tree, in the form of a conical tent with broad base. Under this tent, after earth has been packed around the base, a small quantity, from 15 to 20 c. c., of carbon bisulphide may be poured upon the ground within the tent, and the whole thus left for half an hour. If rightly applied, this remedy will kill all insects within the inclosed area without doing damage to the tree itself. The method here described applies only to trees which have attained their full growth and just after the bearing season. With smaller ones a proportionately smaller amount of the bisulphide should be used.

Not only will the method described for the killing of the larvæ and pupæ of *Cicada* prove effectual for these insects, but it will also be equally so against the white grubs so commonly found among the roots of the cacao tree.

These white grubs are the larvæ of one of the Lamellicorn beetles and probably belong to the genus *Anomala*, the adults of which have been found in cacao plantations in some abundance. In general, the habits of all beetles of this genus are the same. The adult of a very common species is shown by fig. 155, and the larvæ of the form found in the cacao roots in fig. 156. It is not known how or where the eggs are laid, but they are probably deposited in the débris which naturally collects around trees which are ill cared for. The larvæ, upon hatching, have but a very short distance to go, in the case of the cacao, before they find the young tender rootlets upon which they feed with avidity.

These larvæ can be very easily recognized. The form of the body is characteristic. When found they are invariably curled up, assuming this position as a means of defense. The full-grown larvæ measures 3 cm. in length and about 5 mm. in diameter. The long, rather slender, yellowish hairy legs are bent forward at the first joint. In crawling the insect uses them very awkwardly. The head is ocher yellow, shiny, and covered rather sparsely with stout bristle-like hairs. Examination with a strong hand lens reveals the fact that there are no eyes, at least none externally. The dark brown jaws or mandibles are well fitted by their form and position for cutting off bits of the roots upon which the animal feeds.

The body has a somewhat corrugated surface, and upon the back of each segment there is a transverse area covered with fine, brown, very short bristles, which aid the insect in burrowing into the ground. The rear four segments of the abdomen are somewhat broader than the others and are of a darker color, owing to the mass of excrement contained in the alimentary canal.

That these insects do much damage to cacao is evident from their abundance and the fact that they are related to species which are very injurious wherever found in other parts of the world. Living, as they do for the greater part of their lives, below the surface of the ground where cultivation of the plant will not disturb them, they form one of the hardest classes of insects to combat. The effects of their work are such as are not apparent until the weak and dying condition of the tree and its inability to bear fruit tell the grower that it is being killed by some unseen insect enemy.

The full-grown insect, a beetle, is shown in fig. 155. It measures from 9 to 12 mm. in length, is of a shiny greenish-brown color, and the wing covers are very much rounded. Fine striations, running longitudinally upon the wing covers, heighten its sheen. The beetles are usually found upon the leaves or in crevices in the bark, where they appear always to be in hiding. These beetles are very peculiar in their habits, invariably simulating death when they are disturbed. They drop to the ground, where they lie perfectly motionless among the rubbish around the tree until the disturbance has passed. If care be used, a very slight jarring of the tree will cause them to drop to the ground, where, if there be no débris, they may be seen and killed. A word of caution, however, should be given as to jarring the trees. Perhaps no tree cultivated is so susceptible to ill treatment as the cacao. The fruit being so large and heavy may be shaken off by even a strong breeze, and it is therefore evident that jarring when the tree is in fruit will prove most disastrous to it. Only such trees as are just out of fruit, or in the blossom season, should be treated in this manner, and the jarring should be done with the palm of the hand, a gentle blow being delivered and only repeated two or three times for each tree. Anything more severe than this will result in disaster.

For killing the larvæ of the beetle above described the same methods as those employed for killing cicada larvæ may be used.

When this insect is ready to change to the pupa stage, it builds a cell composed of compacted earth. This is somewhat larger than the larva, and as the latter shrinks considerably just previous to the pupal stage, there is sufficient room for it to effect the final change to the adult, allowing for the proper expansion of the wings and wing covers. While in this pupal cell the insect appears as in fig. 157.

While birds, particularly crows, feed most readily upon all forms of white grubs when they are exposed in fields by plowing, it is very doubtful if they perform any appreciable service in the destruction of the *Anomala* beetle, unless it be that they pick it from the trees when it has reached the adult stage. Therefore all efforts against these pests will consist of the destruction of the larvæ at the time of application of remedies for the cicada and the jarring of the beetles from the trees, as described above.

Of all the cultivated plants observed in the Philippine Islands perhaps none has been found that suffers more from insect attacks on the trunk than the cacao. The insect which is of first importance is the flat borer of the cacao. It belongs to the family of long-horned borers, the Cerambycidæ, an adult of which is shown in fig. 158. The damage done by this insect is much greater than that done by any other insect attacking cacao, inasmuch as it not only works for a long period unseen in the trunk, but finally effects the death of the tree, and the damage is hardly apparent to a casual observer until its deadly work is completed.

Ninety per cent of all trees examined in the island of Negros were found more or less completely damaged by this insect. The mode of attack and the results are so characteristic that when once described they will be noticed by the most careless observer, and will be always remembered as the work of this particular insect.

Going through a cacao plantation at certain periods in the year, especially in April and May, one will frequently notice at the bases or upon the trunks of the trees a kind of coarse fibrous sawdust. This may be of a light wood color or of a very dark mahogany red, if there has been a recent rain. One who is not acquainted with the facts might well suppose that this has been produced by the gnawing of some small animal like a rat, though upon closer examination it will be seen that the fibers are too regular to have been thus produced. If the bark be examined carefully, one will soon find a small hole of irregular form, about 1 cm. in diameter, from which there appears to be exuding more sawdust, usually of a dark color and wet, if recently pushed out of the burrow by the insect. If a hooked instrument or a knife be used to carefully remove the flakes of dead bark found around the hole, there will be found more of the same material underneath. If the search be continued, following the line of a now well-marked burrow, the chances are that at its end, whether just below the bark in the sapwood or within a deeper burrow toward the heart of the tree, a large yellowish grub with darker head and still darker brown jaws, will be found. The body is larger toward the head and somewhat flattened, giving the insect the name flat-headed borer. The body segments are well defined, as shown in fig. 159. The darker color of the hinder part of the body is due to the fact that the digested wood becomes colored by the juices in the alimentary canal of the larva. It would be well to state here that the fibrous masses of wood found in connection with this insect have not been used as food, but were simply cut away in the process of making the pupal cell and in filling up its entrance, in order that the grub may not be disturbed in its transformations to the pupal and adult stages.

This larva may well be described as a footless grub, one which is perfectly helpless when removed from its burrow, for when once taken out it is not only at the mercy of predacious insects like ants, but is of itself so helpless that it would soon die from lack of moisture before it could reach a place of safety.

The full-grown larva measures 40 mm. in length and about 4 mm. in diameter at the middle of the body. Its powerful jaws or mandibles enable it to feed readily upon the hardest parts of the wood in which it lives, and specimens have been found which have excavated tunnels 50 cm. long, in addition to the irregular blotch-like cavities which are formed just beneath the bark at the beginning of the attack.

The habits of this insect are very similar to related species in other countries, as the maple borer, *Plagionotus speciosus;* the sawyer, *Monohammus confusor;* the round-headed apple borer, *Saperda candida;* the oak pruner, *Elaphidion villosum.* The female lays her egg in a small puncture in the living bark of the tree and as soon as the young grub hatches it begins its work of tunneling the bark, the tender growing wood, and eventually the harder portions of the tree. Were it true that a single borer did its work in the trunk the damage done, though considerable, would not be so serious a menace to the life of the tree. But when several borers appear simultaneously in different parts of the trunk they soon succeed in girdling it, after which the tree is sure to die. Figs. 160, 161, and 162 show several large-sized branches killed in this manner. The grubs having destroyed one side of the tree, the latter puts forth its strength in efforts to heal up the wound, causing an abnormal growth to bulge over the bare space left by the insect attack. The wood and bark increase in thickness on the opposite side. Other grubs attack this part, which is particularly rich in food material, and thus by these successive attacks the living parts are all destroyed and the tree girdled.

Trees have frequently been observed in which, on a branch from 4 to 7 cm. in diameter, there would be a strip of only 1.5 mm. of living wood, and yet this branch would be giving forth leaves above the wound. Of course the latter were small, being ill-nourished, and no fruit could be expected upon such a branch. This illustrates the remarkable vitality of the cacao, and probably explains, too, its extreme susceptibility to injuries of any kind.

An interesting feature of the work of the flat-headed borers is the manner in which the excrement is packed behind it in the burrow, sometimes so solidly as to simulate the wood itself. It can, however, always be distinguished by its granular appearance as distinct from the fibrous structure of the wood. These filled burrows are frequently encountered in timber when it is sawed for building and other purposes. Wood having this appearance is called "wormy." A characteristic burrow of one of these larvæ is shown in figure 163, with also some of the frass as left behind.

When the grub is about to pupate it burrows toward the heart of the tree and upward, thus forming an oblique canal which when a short way in is changed to a vertical direction and is thus parallel with the wood fiber. Into this burrow the insect retires and changes its position so that the head is toward the opening. Within a very short time after the larva has entered this retreat and has packed in the fibers to close up its doorway, it sheds its skin as a grub and assumes a form which, upon closer examination, shows that it possesses characteristics of a beetle. The legs, antennæ, wings, and wing covers may all be readily distinguished if a careful examination be made. Unfortunately there have not yet been sufficient observations upon this insect to enable me to state the length of time during which it remains in the larval and pupal stage. On the 11th of March, 1903, a full-grown beetle was taken from a tree near one in which larval pupal forms had been found at an earlier date of the same year. This would seem to indicate that the period for the pupa is from four to six weeks, possibly not so long.

The adult, after its outer covering has become thoroughly dry and hard, subsequent to its change from the pupa, begins the work of gnawing away the material which as a larva it had packed in the mouth of its burrow, and it comes forth a very beautiful creature, entirely unlike the uncomely grub which had been doing the damage. Its length is 25.5 mm., its greatest breadth 6.5 mm. The antennæ in the specimen before me, measure 44 mm. When the insect is at rest, the antennæ are carried back over the body, projecting beyond the tip of the abdomen. The antenna has 11 joints, the second from the head being much thicker than the others and having transverse corrugations on lines upon its upper surface. Each succeeding joint, except the three last, is knobbed at its extremity and bears a spine on the hinder edge. The eyes, which are black and composed of what appear to be a number of fine jet beads, are crescent shaped, and are placed around the hinder edge of the sockets of the antennæ. The thorax is very markedly corrugated transversely and is covered with fine, golden-brown hairs, which give it and the wing covers, which are similarly marked, the appearance of a beautiful brocade velvet. The legs are rather long and slender. They are covered with fine hairs, as is true also of the under surface of the body. The feet are provided with a pair of hooked claws, which aid the insect in clinging to the bark. In the act of egg laying the female grasps the bark firmly with all her feet, and is thereby enabled to insert the ovipositor into the bark.

The beetles of this family make a peculiar noise when disturbed or captured. It is similar to the sound produced by rubbing the finger nail over a very fine file, and is made by the friction of the tip of the wing covers on the surface of the abdomen.

The question of combatting this insect is a very serious one, as the methods employed must at once be easy of application and likewise effectual at the time when the insect is likely to begin its greatest damage. The beetle almost invariably rests upon the bark, which is so nearly its own color as to make it very difficult to detect. It is therefore evident that any attempts to thus discover it and rid the trees of this pest by hand picking would prove practically useless. In order, therefore, that the insect be repelled from the bark, something must be used which will prove at once distasteful to it and harmless to the tree. Probably the very best method with young trees, when recently set and until they reach an age when the bark will not be susceptible to the effects of any strong wash which may be applied, is the complete enveloping of the trunk of the tree by means of cage protectors made of a coarse grade of abacá or "sinamay," such as is used in the Visayas for mosquito netting, and which has a net sufficiently fine to prevent the entering of the adult for egg laying. This material is so cheap that it could be used constantly, even until the trees have attained a considerable size. The bags are made of a cylindrical form, open at both ends, and having a draw string in one end. They may be slipped over small plants and the lower ends held close to the ground, either by embedding in earth or by the placing of a stone upon the lower edge. In the case of larger trees, where it is impracticable to slip this bag over all the branches, it is well to simply use a straight piece of cloth, putting it around the tree, and after doubling the edges together in the form of a hem they may be either sewed with coarse stitches or pinned by means of sticks of bamboo made in the form of toothpicks. Figure 164 is an illustration of a bag which was used for the protection of the upper parts of the trunk in order that during investigations the adults which emerged from the tree might not escape. In figure 165 a tree is shown protected by one of these bags. If opened at the bottom and held close to the ground by stones or earth this would serve admirably for keeping off the beetles. Wire screening would serve equally as well were it not for the fact that the extreme dampness would cause it to rust and thus quickly become useless. In the United States a heavy grade of tarred or roofing paper serves the same purpose, but its cost would be against its general use in the Philippines.

Where it is not practicable to use the method described above, some repellant to the insects should be applied to those parts of the trunk which are most likely to be affected. Inasmuch as these repellants are simply supposed to keep the adult insect from laying her eggs, it is very obvious that they should be applied before any insect has had a chance to deposit its eggs in the tree trunk. If the grub has once entered the bark, no application of remedies externally will have the least effect upon it, and other means must be taken. These will be spoken of later. Any strong-smelling substance, such as fish oil, tar, or pitch, which will adhere to the tree, or pure crude petroleum would prove effectual, but perhaps the best and most easily applied material for warding off the attacks of this borer is what is known as the soap and carbolic acid wash. This is prepared by dissolving 4 liters of soft soap in 4 liters of hot water and adding one-half liter of crude carbolic acid. This mixture should stand for at least twenty-four hours, or until it has become perfectly dissolved. Into this should be poured from 32 to 40 liters of rain water, and the whole carefully stirred until thoroughly uniform. It may then be used with a broad paint brush or swab on the end of a stick, covering all the parts of the trunk and branches which might be supposed to offer a place for the borer to lay its eggs. No fear need be had that this mixture will injure the trees if properly prepared in the proportions given. The period from the 1st of April to the 1st of June would be the best in which to apply this preventive, as it is during this time that the beetles come forth and are ready to lay their eggs.

An excellent preventive which has been used most successfully against the peach borers in the United States, and which would probably prove of value equal to that of the carbolic wash, is a preparation composed of lime, coal tar, and whale oil soap. This mixture may be put on in a comparatively thin coating, as ordinary rains do not easily wash it from the trees. It must be thoroughly applied to all parts of the tree likely to be attacked by the borers.

Tobacco dust has been advocated by some fruit growers in America as a preventive of the borers. The author leaves this matter until more thorough experimentation in the Philippines shall determine the advisability of recommending it for general use. If it be found an effectual remedy, there would be a decided advantage in employing it in lieu of insecticides which would have to be brought from abroad.

An effective measure to be used against the grubs which have already entered the tree is to carefully search for evidence of their existence beneath the bark, and when

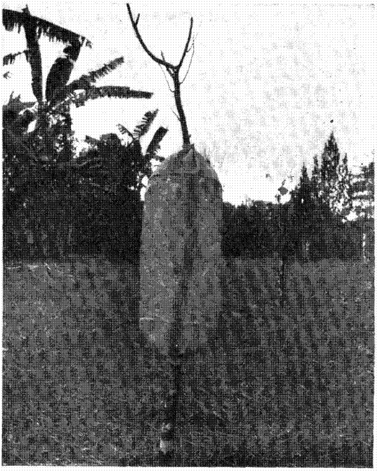


FIG. 164.

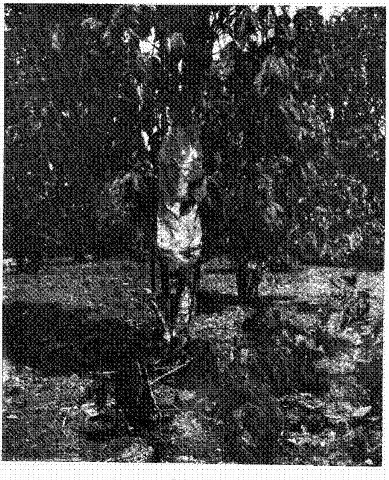


FIG. 165.

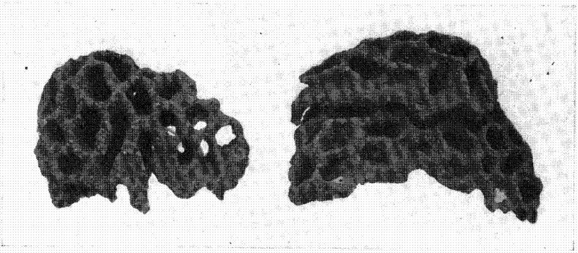


FIG. 168 *a*.

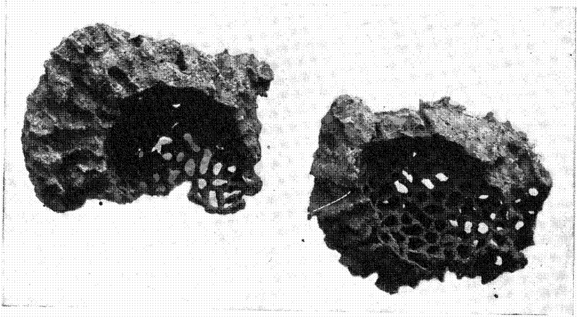


FIG. 168 *b*.

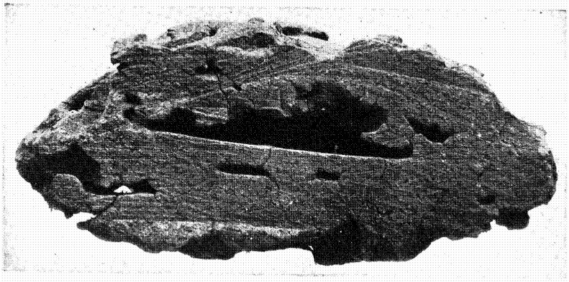


FIG. 169.

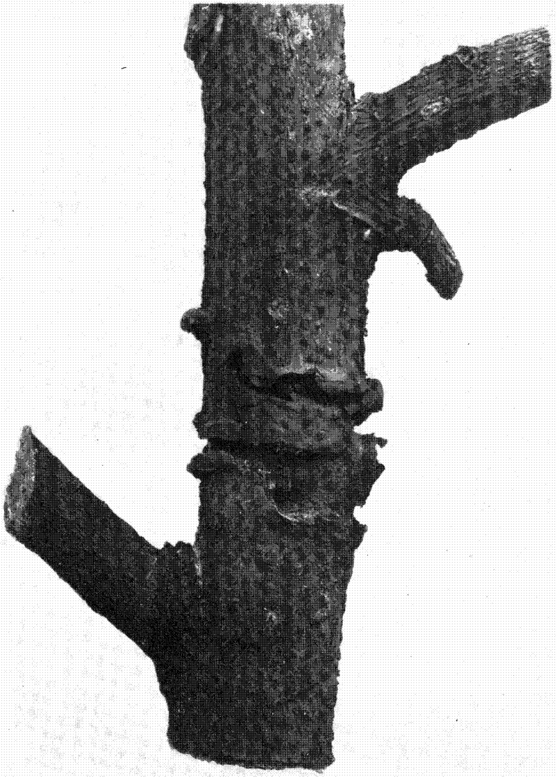


FIG. 171 *a*.

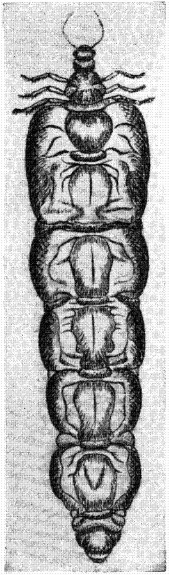


FIG. 166 (ORIGINAL).

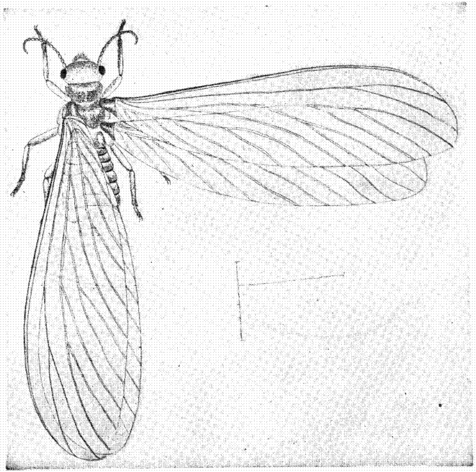
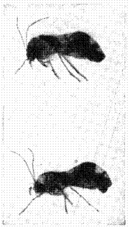


FIG. 167 (LINE SHOWS NATURAL SIZE).



INSECTS SHOWN IN FIG. 170, SOMEWHAT ENLARGED.

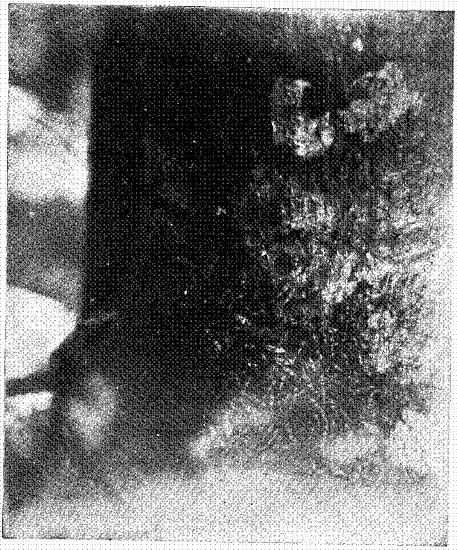


FIG. 170.

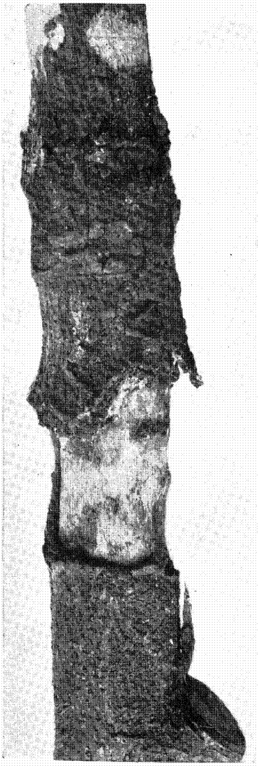


FIG 171 (ENLARGED).

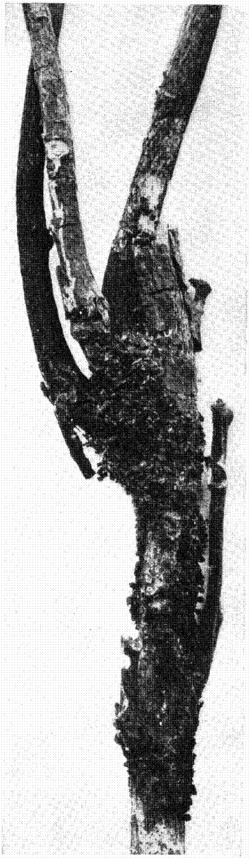


FIG. 172 (ENLARGED).

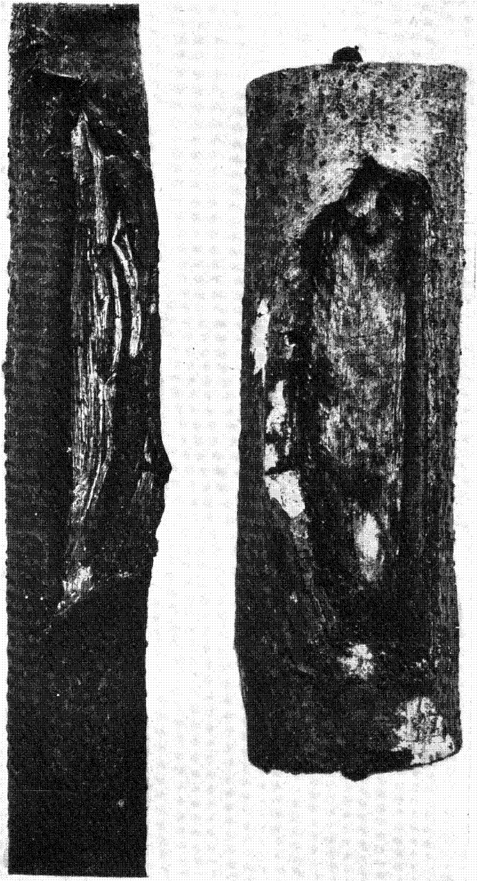


FIG. 172.

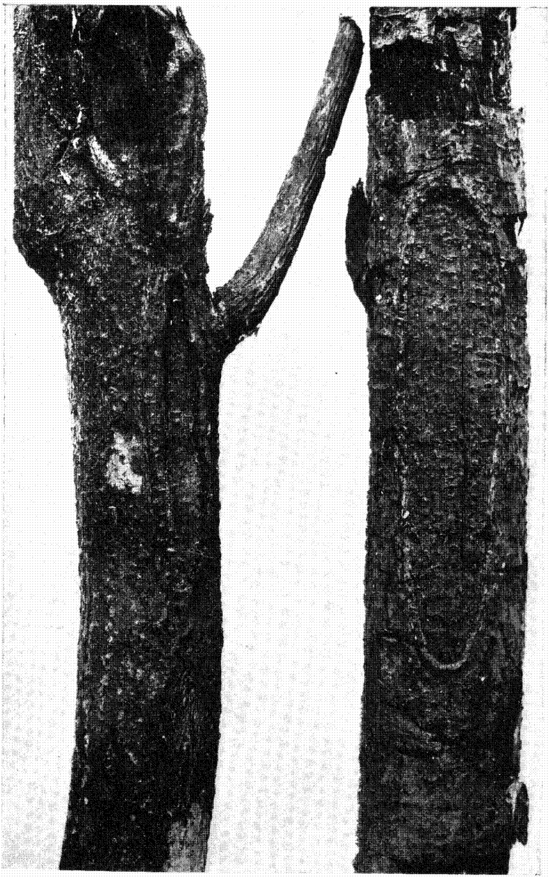


FIG. 172.

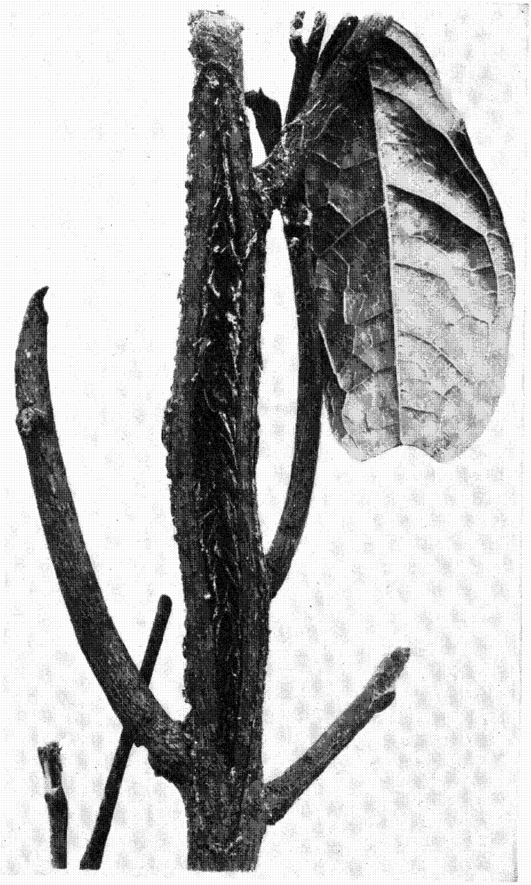


FIG. 173.

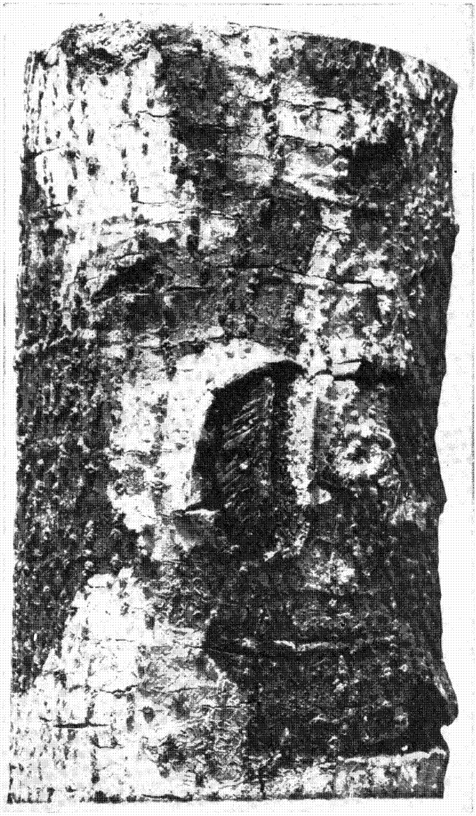


FIG. 174.

they are located to thrust in a stout piece of bent wire, with which they can be crushed. It is not necessary to extract the crushed insect, as when so injured it can not transform further, and there will be no danger of its coming forth as a beetle.

The fact must be constantly borne in mind by those who would grow cacao successfully in these islands that vigilance, not only over those charged with the work of caring for the trees, but also personal inspection of the orchards themselves by the owners will be necessary to detect not only the presence of these insects, but also a large number of other forms whose insidious working in places in which it is not easy to get at them renders them all the more pernicious. As in a clean house or in a clean city, diseases are less liable to enter and play havoc, so in a clean cacao orchard insects find less favorable fields for their ravages. This means that thorough and scientific pruning, careful cultivation as set forth in Lyons's bulletin on Cacao Culture,[a] and a constant care must be taken against insect and other pests. Clean ground around the cacao trees proves less inviting to all kinds of insects which would be liable to lurk in the rubbish and dead leaves which often litter the plantations so far observed.

Another insect which has proven seriously destructive to the trunks of cacao trees is the "white ant," or termite. This insect, described as being destructive to the roots, does not by any means confine itself to these parts of the tree. (Fig. 147 shows the work done in the living trunk of a cacao which had first been seriously injured by the borer.) When once the white ant becomes abundant in a tree its life is practically over, unless the measures suggested be followed before the insects have extended high into the tree. These termites have an underground cell in which the queen mother of the colony is confined. Owing to her great size she can not leave this cell, and performs no other function save the laying of eggs, with which her enormous body is distended. (Fig. 166 shows a female, natural size, of a species closely related to the one which damages cacao trees. Fig. 167 shows the same kind of insect before her body has become distended with eggs.) Unless this queen mother be destroyed in some way the colony will go on multiplying indefinitely, it matters not how many of the ants found in the tree be destroyed. There are always thousands of workers in the ground chambers of the nest to attend to the rearing of the enormous brood. (Fig. 168 shows the cells where the young anay are reared.)

In order to find out approximately the number of eggs laid by a female, a complete queen cell in which the queen mother was confined was dug out. (Fig. 169 shows the appearance of a cross section of this cell.) The female was carefully watched for several hours and was seen to be continuously laying eggs. These eggs were carried away in tiny adherent masses by the workers. A careful watch was made for one minute, and instead of allowing the workers to remove the eggs during this period the mass was carefully picked up with a fine forceps as fast as it had assumed the size of those previously carried away by the workers. A count revealed the fact that during one minute 165 eggs had been laid by the queen mother. No estimate of the weight of this mass was made, but it is safe to say that it represented not more than $\frac{1}{1000}$ of that of the female when fully distended. Some idea can be gained from this of the wonderfully prolific character of the termite and the futility of attempting to destroy a colony without first killing the queen mother.

The same species of large black ants which were mentioned as attacking the tree below the crown and among the roots will likewise be found in the trunk, especially after the attacks of the borer and the termite or anay. They do not attack the trunk very high up, seeming to prefer living half beneath the ground. The same treatment recommended for this insect when found among the roots will apply to it when found in the trunk of the tree.

A little insect which is often rather abundant upon the trunks of cacao trees is a species of Psocidæ. This is perfectly harmless, feeding only upon the lichen growths which are to be met with. It should not be confused with the winged forms of plant lice, which are very injurious. This species of *Psocus* is red and black; the body being red and the wings mottled and of a smoky color. They are often found bunched together in considerable numbers on the lower trunk near the ground, and when disturbed scurry to one side like a flock of sheep, leaving a bare spot where the disturbing influence touched them. Among these aggregations the larvæ, which are wingless, the pupæ, which have tiny wing pads, and the adults, which have fully developed wings, may be found. (Fig. 170 shows a portion of a cacao tree trunk covered with these insects.) Since they feed upon substances entirely foreign to the life of the tree and simply use the latter as a place of abode, they may be classified as harmless.

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[a] See Bul. 2, Phil. Bureau of Agr., 1902.

Many insects, like caterpillars, will be found resting upon the trunks of cacao trees during the day, while at night they will be found feeding upon the leaves. These are often so nearly of the same color as the bark that they escape all except an eye trained to look for such things. One particular species of caterpillar belonging to the family Lymantriidæ is so nearly like the caterpillar of *Porthetria* (*Ocneria*) *dispar*, the gypsy moth, as to indicate a very close relationship between the two, but as I have not yet succeeded in rearing the adult, the insect has not been determined. The habit of placing the cocoon or nearly naked brown chrysalis in the twigs and in holes in the bark is almost identical with that of *Porthetria*.

The caterpillar will be described when the insects which injure the leaves are discussed. Three very serious insect pests which attack the small branches and twigs, girdling the bark of the latter at their juncture with the stem, have been found in the larval stage, but all attempts at rearing or finding the adults have so far proven failures. (Fig. 171 will show how thoroughly the larva of one has done its work of girdling a twig which was 26 mm. in diameter. Fig. 171*a* shows a twig 13 mm. thick, which is also completely girdled by the insect.)

A peculiar and interesting habit of the larva, which first attacks the twigs to girdle them, is that of using its excrement, together with silk, for covering up the burrow or retreat in which it lives. This is very neatly done by fastening the particles together with a kind of silk and these pellets or particles of frass are so nearly the color of the bark from which the animal has obtained its food that the difference between this and the sound bark is often not noticed except after closest observation. This larva is of a dull grayish color with a brownish head. Its body is sparsely covered with stiff bristles and its general habits are similar to those of the Tortricidæ.

The second larva is undoubtedly a Cerambycid, but as has been said, it has only been found in this stage and can therefore not be identified at present.

The destructive work of *Cicada* has already been mentioned in reference to insects which affect the roots of the cacao, and its habit of laying its eggs in the twigs make it likewise one of the insects injurious to the twigs and branches. The mode of treating twigs thus affected would be to cut off and burn all twigs in which the cicada eggs have been laid; one will frequently come upon a twig or even a good-sized branch which bears a peculiar scar like that shown in fig. 172. If a careful examination be made, this will be seen to contain shriveled eggshells about 4 mm. in length. Twigs will be found like that represented in fig. 173, in which the eggs show very plainly. The adult which lays these eggs has not yet been found, but from the general appearance of them, it is very likely that the insect is an Orthopteron; that is, belonging to the order of grasshoppers, crickets, etc., and may be one of the katydids, some very large species of which have already been taken in cacao groves. *Microcentrum retinervis*, the angular-winged katydid of the southern United States, lays its eggs, which are of about the same size as those shown in fig. 174, upon the edges of leaves and upon the stems of the trees which it inhabits, and therefore it may reasonably be supposed that the destructive insect in the case of cacao is a related species.

With many insects of this and other species affecting the cacao, long periods of observation and the collection of more material will be necessary in order to become thoroughly acquainted with their entire life history. In many instances thus far only one stage, or the work of the insect doing the damage, has been obtained.

One of the most serious pests of the leaves, tender buds, and flowers is a species of black plant louse. This insect attacks the young buds even before the leaves or the flowers have opened. The tiny eggs are laid in the folds of the buds and the bud scales, beneath the stipules of the leaves and in the crevices of the unopened sepals of the flowers. They are so minute that they can only be seen with the aid of a magnifying glass. As soon as the young hatch, they pierce the skin of the twig upon which they rest and begin sucking the plant juices. Some broods of plant lice give birth to living young, which in turn lay eggs. This question of the alternation of the mode of reproduction is very interesting to the student of biology, but has little value economically, at least in this latitude. The young plant lice resemble the adults in form. They are, of course, much smaller, and have no wings, but as certain forms of the adults are also wingless this feature alone will not aid in distinguishing the stages.

Plant lice are provided with a pair of spine-like projections which are like little tubes on the back of the abdomen, and which secrete a waxy substance much sought by ants. This substance is commonly known as "honeydew." Its nature is not clearly known. Wherever there is a colony of plant lice the surface upon which they rest will very often be found to be sticky and glistening, as though covered with sirup. This is the "honeydew" secreted by the plant lice. It is for the purpose of collecting this that ants invariably attend a colony of plant lice, caring for them assiduously in return for the "honey" which they secure. They frequently carry the plant lice from place to place when the leaves or twigs upon which the latter have been feeding become dry and hard.

Even though only a single plant louse be found upon a leaf or flower, it is almost invariably attended by an ant and sometimes by two or more. Thus cared for, it is little wonder that the plant lice multiply and flourish to a remarkable extent. (Fig. 175 represents the different stages of the plant louse. It will be noticed that at *b* the pupæ are distinguished by the tiny wing pads which contain the wings.) These insects feed in all stages from the larva to the adult, and therefore their damage is considerably greater in proportion than that done by insects which feed only in the larval stages, like Lepidoptera, Diptera, and Coleoptera. Their minuteness appears to be fully compensated for by their numbers, and so the cacao grower has to be ever vigilant in order that he may successfully combat them.

The immediate effect of the attacks of the plant lice is to cause a drooping or wilting of the leaves, flowers, or flower stems which they attack. This is followed by a distortion of the part, the leaves curling toward the under side, where the plant lice are usually found. This shriveling is very marked upon some trees, and when the leaves have attained their full growth they will be found to be undersized and broken because of their efforts to outgrow the attack. Flowers, when attacked by the plant lice, shrivel and die without producing fruit. Occasionally the plant lice are found upon the very young fruits, the skin of which is almost as tender as the young leaves. Invariably fruits thus attacked either die from exhaustion, or if they survive, are very much distorted, presenting, instead of the regular, even lobed appearance of the perfect pod, a scarred, smooth side which has no semblance of the characteristic ridges. In this way the pods are formed in which the tip, instead of being straight, is twisted by arrested growth on one side and by the normal development on the other. (Fig. 176 shows a fruit thus distorted and also a perfect fruit.)

When the fruit pods have attained the size of a hen's egg, they are not subject to the attacks of the plant lice, and thus it will be evident that any remedy should be applied before this period.

As a means of treating plant lice upon the flowers and leaves of cacao, there is no better material than kerosene emulsion. There are several ways of making and applying this insecticide, but the best preparation for this purpose will be the kerosene and soap emulsion. This, if properly prepared and applied according to directions, will be found to be harmless to the most delicate parts of the plant. For its preparation see the chapter on insecticides.

In applying the kerosene emulsion some kind of spray pump should be used to facilitate the uniform distribution of the spray and to enable the workman to reach the higher branches of the tree with the emulsion.

Another enemy of the young cacao leaves which is likely to prove of considerable importance is the black thrips. This minute insect may escape even a close observer if he does not know the signs which indicate its presence. As in the case of the plant lice, the injury caused by the thrips makes the leaves curl up, as shown in fig. 177, but not as markedly as with the former. If one carefully examine a few leaves which show evidences of curlings, he will find upon the underside a number of very slender black and red objects moving very slowly from place to place. The black ones are the adults, the red ones the young thrips. The rear part of the abdomen is decidedly pointed, and the thorax bears a spine on each side. These insects are provided with sucking mouth parts, and cause an injury to the leaf similar to that caused by the plant lice. They may be combated by the same means employed to destroy the latter, and large numbers of them will be killed when the trees are sprayed for the Aphids. (An adult thrips is represented, much enlarged, in fig. 178.)

Another insect which, while not occurring in great abundance at the time when observations were made, is likely to prove a pest to the cacao, is the large yellow scale represented, magnified, in fig. 179. Its egg is shown at *b*. The adult female measures 17.5 mm. long, 13 mm. wide, and 9 mm. high. It is of a light salmon yellow color and is covered with a fine powdery substance. Beneath the scale secretes a white pubescence which is fibrous in structure. The upper surface is corrugated; the hinder part of the body is much higher than the forepart, and when at rest upon the twig or leaf the black legs and antennæ are completely hidden by the shell-shaped body. The forward part of the body is slightly notched. When the animal is disturbed and moves from place to place, the tiny black antennæ and tips of the black feet may be seen protruding from beneath the body. In February and early March these insects will always be found with the space beneath the dome of the body completely filled with tiny orange yellow eggs, which are 1 mm. long and 0.6 mm. wide. It is not yet known when the young hatch nor has anything definite been ascertained concerning the full life history of this insect. Further studies will elucidate points concerning this and other scale-like insects of the cacao.

The same method employed in ridding the trees of the Aphids will apply to the combating of the large yellow scale. Its soft body will make it peculiarly susceptible to the effects of kerosene emulsion.

Very frequently there will be met in the cracks and crevices under the dead bark and in holes where limbs have been broken off from the cacao a beautiful, irridescent, blackish-green or blackish-purple beetle, with very convex wing covers and antennæ which have the appearance of a string of beads. This beetle belongs to the family Sphindidæ, a class of beetles whose larvæ feed upon dry fungi and decaying vegetable matter, and which are not injurious to the tree. When disturbed these beetles readily simulate death, and will drop to the ground until the disturbance has passed. They have been found in fair abundance in all cacao plantations.

The beetle measures 14 mm. in length and 5.5 mm. in width, the wing covers being 9 mm. long. The wing covers are marked by a series of nine longitudinal lines, which are punctuated by fine dots. The under surface of the body is of the same color as the upper (see fig. 180).

Occasionally there may be found upon the under surface of the beetle tiny light-brown roundish mites, which are parasites. This is a thing which is very common to many Coleoptera, especially those living in dark or obscure places.

Associated with the beetle may be found several species of cockroaches, some very pale yellow and about 15 mm. long, others mottled buff color, 20 to 25 mm. long, and still others which are about 35 mm. long and of a reddish-brown color. None of these do damage to the trees, as they live upon the decaying matter found in the crevices and wounds.

Other harmless forms pertaining to Thysaura, Coleoptera, Corrodentia, and Orthoptera have been met with upon the trees, but a description of these minor insects and of their life histories and habits will be left for a later report. In any attempt at treating the trees for injurious insects many of these will inevitably be killed.

The two principal destructive insects found upon the leaves are a species of caterpillar of the family Lymantriidæ, and another of the family Eucleidæ. The caterpillar of the former can be easily recognized by its size and its hairy appearance. When full grown, and ready to transform, it measures 33 mm. in length and 10 mm. wide, without the hairs, which add 12 mm. to these dimensions all around, making the entire caterpillar occupy a space of 53 mm. by 30 mm. on the surface of the leaf. The adult and the egg-laying habits of this insect are not yet known, but it is probable that the female lays her eggs in patches upon the twigs, covering them with soft down from the outside of her own body, like a closely related species found upon the Ylang-ylang and the Talisay trees. These caterpillars, as has been stated, have the habit of feeding at night and resting upon the branches and the trunk of the tree during the day. When disturbed they raise the head and twitch the forepart of the body from side to side. If the disturbance be continued, they drop either to the ground or to a lower limb. The color is a dull gray, with a few reddish markings. The head is very large, grayish, and marked by darker patches of small dots. The hairs, which project forward from the neck, give the insect the appearance of wearing a ruff. When at rest upon the bark, the false legs of the abdomen, ten in number, are spread out beyond the sides of the body, firmly grasping the surface upon which the insect is resting. When the caterpillar is about to change its skin, or moult, a process which it perform five times before changing to the chrysalis, the six true feet are drawn up together, the head is drawn down toward the legs, and the fore end of the body is elevated. This insect, before pupating, finds a convenient place at the fork of a small twig, or in a crevice in the bark, and there it spins a very poor apology for a cocoon. The cocoon looks more like a wide-meshed basket than a true cocoon, and doubtless serves simply to keep the large brown chrysalis from falling to the ground. Unfortunately several of these chrysalids, which were put into a box for rearing, transformed to the adult stage in transit to Manila from the place of capture, and were so badly damaged as to be unrecognizable when the box was opened.

In addition, to the long hairs which cover its body this caterpillar is provided with short stout bristles, 3 mm. long. They grow from tubercles on the upper parts of the abdominal or thoracic segments, and are spread out in tuft form. These bristles are very sharp, and when the observer is pricked by them the sensation is a very painful one. It is claimed by Filipinos that these animals are very poisonous, and undoubtedly this belief comes from painful experiences with their poisonous spines. On many people the prick of these spines causes great swelling and inflammation, which may continue for some days. This is due to the fact that the spines work their way through the epidermis into the lower skin and there remain for some time. If one handles these insects by mistake the best way is to carefully pick out all the spines with a pair of pincers, using a magnifying glass, if necessary, to aid in the work.

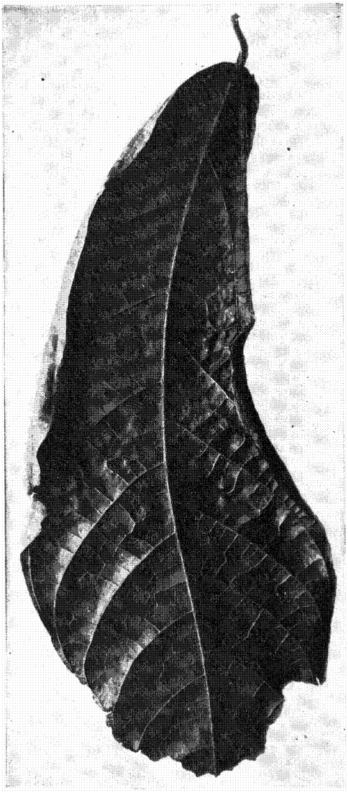


FIG. 117.

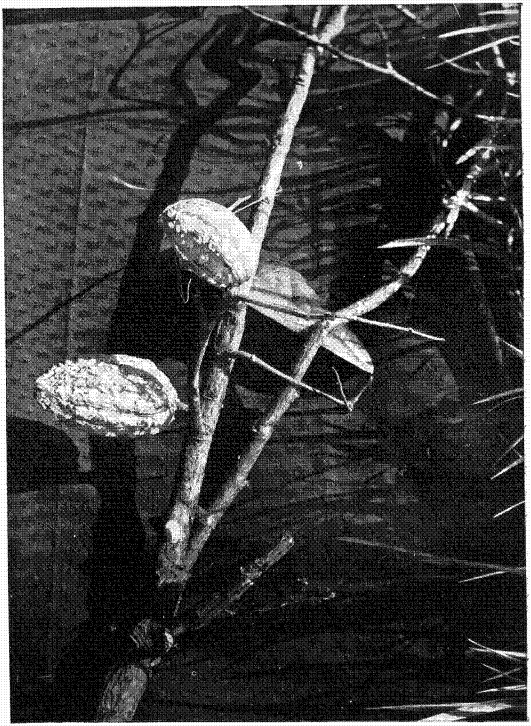


FIG. 176.

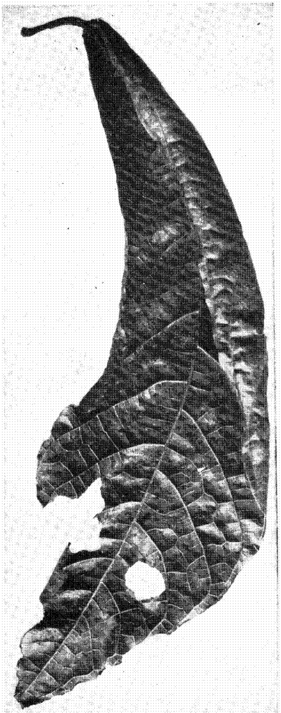


FIG. 177.

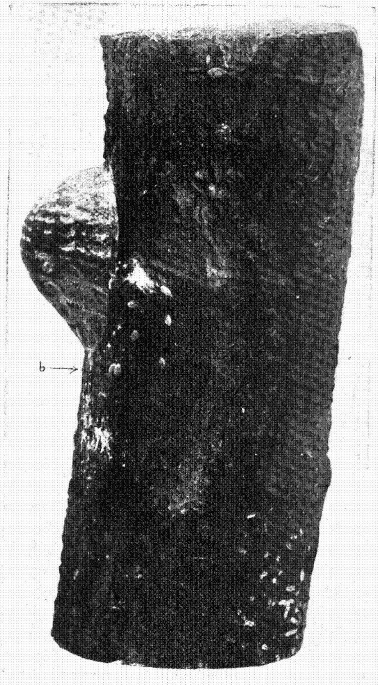


FIG. 179.

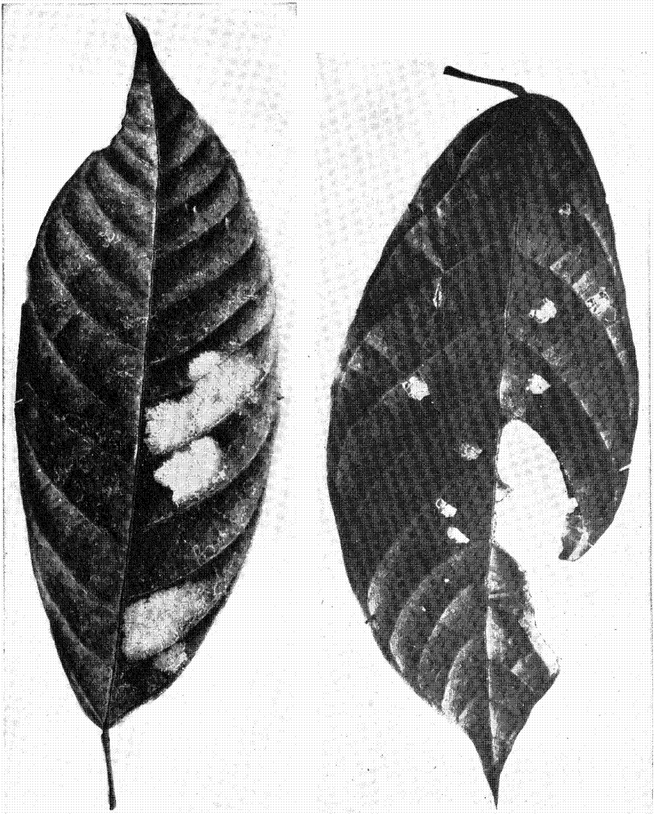


FIG 183.

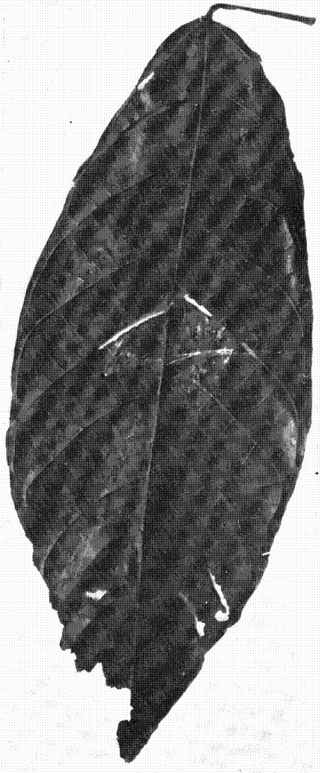


FIG. 187.

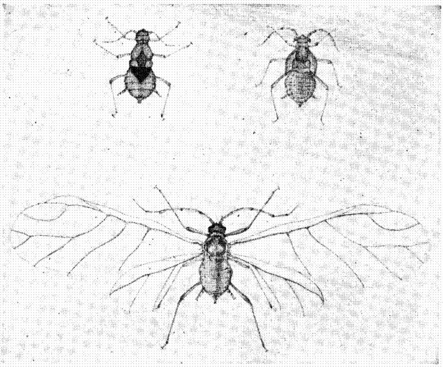


FIG. 175.

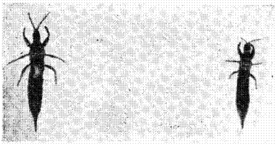


FIG 178.

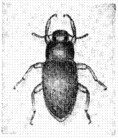


FIG. 180.

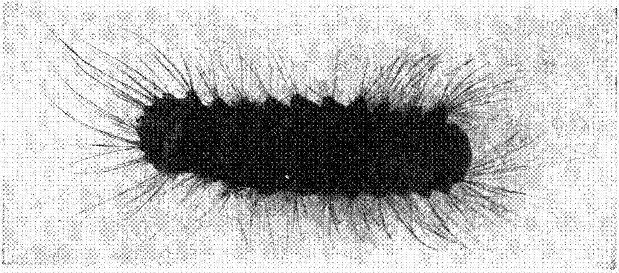


FIG. 181 (ENLARGED 2 DIAMETERS).

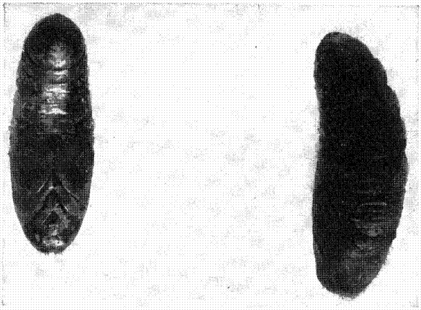


FIG. 182 (ENLARGED 2 DIAMETERS)

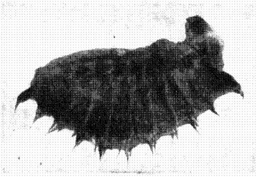


FIG. 184.

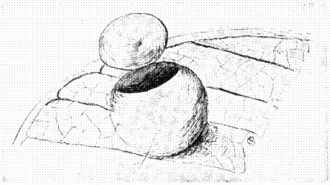


FIG. 185 (ORIGINAL).

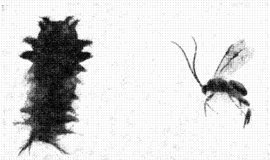


FIG. 186.—SHOWING ALSO HYMENOPTEROUS PARASITE.

The pupa is likewise covered upon certain areas with very minute spines not more than 1 mm. in length, which have the same properties as those upon the caterpillar.

The pupa of this insect is much shorter and stouter than the larva, measuring only 23 mm. in length. Fig. 181 shows the full grown larva, and fig. 182 the pupa.

The other caterpillar, which is nearly as severe in its attacks as the hairy form, is what it commonly termed a slug caterpillar. The slug caterpillar is so called from the fact that instead of possessing well-developed legs and prolegs (false abdominal legs) it has the underside of the body nodified so that for its entire length it is closely applied to the surface upon which the caterpillar crawls. The form of the caterpillar is most striking, and once recognized these larvæ can not be mistaken for any other. The body which in the full grown larva measures 9 mm. long is shaped much like a slug or snail, except that it is perfectly square across the back, the sides being also perpendicular to the back. The very pronounced margin which separates the side from the back is armed with a series of erect spines of a mottled brown color with black tips. There is also a row of these spines on each side near the ventral or lower surface of the caterpillar's body. A peculiar little tubercle armed with two of these spines projects from the rear of the body and slightly upward. When feeding, the caterpillar protrudes its head from beneath its spiny armor, and when disturbed it can immediately withdraw it, pulling the forepart of the body down over it for protection. When touched upon one side the insect immediately doubles over toward that side, just as a person would do if tickled. If touched upon the opposite side it performs a similar movement in that direction. The general color of the insect is dull brown, but the under surface is pale, almost white, and very smooth. The insect secretes a kind of slime which is evidently useful to it in its movements upon the leaves, serving in place of legs to hold it. When it is about to transform to the pupa, it spins a very tough, thick cocoon which is nearly spherical in form and is attached to the leaf or the twig. This little cocoon is brown and very smooth and glossy. It bears no resemblance to anything pertaining to an insect except to the little galls formed by certain hymenopterous insects upon trees like the oak, etc. It looks more like a little dry brown fruit of some kind.

The damage that the caterpillar does to the leaves is shown by fig. 183. As the eggs are always laid upon the underside of the leaf, the insect begins by eating off the lower skin or epidermis, leaving only the veins which give the peculiar skeletonized effect shown in the figure. The insect, enlarged is shown at fig. 184, while the cocoon from which the adult moth has escaped is shown at fig. 185. In escaping, the moth pushes off a little round lid in the cocoon.

There is another member of the same family which, when full grown is somewhat larger, of a bright yellowish green with a peculiar brown mark upon the back and having a double row of tubercles on either side from which grow tufts of bristles or spines very much like those described on the hairy caterpillar of the family Lymantriidæ. This caterpillar, shown enlarged by fig. 186, has habits similar to those of the other species of Eucleidæ except that it eats holes in the leaf, as shown by fig. 187.

This insect in the larval stage is attacked by a little hymenopterous parasite which lives within the body, devouring the fat and finally the internal organs of the caterpillar. When this parasite has reached the stage for transformation to the pupa, it spins its white silken cocoon within the caterpillar's body, and the latter may often be found dead upon the leaf looking as though it were still alive, but motionless.

Inasmuch as these three insects, like all caterpillars, obtain their food by biting, they will be susceptible to any poison which may be placed upon the leaf and which they can take into the mouth. Among the many insecticides prepared for this class of insects, those that are among the best are arsenate of lead, Paris green, and hellebore, the first named being probably the cheapest and most effective. When once the solution of arsenate of lead is dried upon the leaves, it will stand considerable rain before it will be finally washed off, and it is doubtful if it would be all removed before the insects would have secured a sufficient quantity to kill them. As obtainable in the United States, the arsenate of lead is a commercial compound, but it can be made in the quantity necessary by following the directions for its preparation in the chapter on insecticides. The preparation and use of Paris green, with other useful insecticides, will be treated in the same chapter.

Of the family Chrysomelidæ there has been found at least one species which does damage to the leaves of the cacao. As this beetle is very small and of an obscure color, it might be readily overlooked when searching for insects upon the plant. The female is about 4.5 mm. in length, is of an oval form, and very much rounded upon the back. The male is smaller, being 3.5 mm. long. These insects vary from light to dark brown, the majority being a very dark brown. The wing covers are very glossy and are marked by longitudinal dotted lines extending from the base to the tip. The adults are quick in their movements both when walking and flying, taking readily to wing when disturbed or dropping quickly to the ground. They are very difficult to catch unless a bag is held beneath the leaf upon which they are resting and the latter be shaken. Even then, upon alighting in the bag they will almost immediately fly away unless promptly killed. The eggs of these insects have not been found, but like most beetles pertaining to this family, they are probably laid upon the lower sides of the leaves in patches in which the single eggs stand on end. The young grubs are very peculiar in form, being shaped like the larvæ of ladybirds, Coccinelidæ, except that their abdomens are thicker at the rear. They move very slowly and when disturbed cling to the surface rather than drop to the ground. Their bodies are covered with short black spines as a means of protection.

When young, these insects feed only upon the lower epidermis of the leaf, but as they grow larger they eat away both upper and lower skin, leaving a few of the larger veins which are too tough.

The adults, as well as the larvæ, are leaf feeders, eating through the entire substance of the latter.

As many as 20 of these beetles are sometimes found upon the same leaf, and, as each consumes an area equal to about ten times that occupied by his body, it can be readily seen that the damage done by the cacao-leaf beetle is considerable. For the combating of these insects a spray of arsenate of lead is recommended as fatal to both larvæ and adults.

Further observations are necessary in order to determine where these insects pupate. Most of the leaf eaters pupate in the crevices of the bark and in dried leaves and other secluded places, such as wounds in the tree and rubbish which accumulates around neglected trees, and doubtless these insects have the same habits. (Fig. 188 represents the full-grown beetles, *a* being the male and *b* the female, all much enlarged. Fig. 189 shows the larva of a related species.)

Cacao leaves are affected by at least two species of scale insect. This is an insect which, in the larval stage, exudes a waxy secretion, which soon forms a shell or scale which soon completely covers the insect so that none of its body is visible. This is of peculiar form, according to the species. Some are long and narrow, others are elliptical, oval, or circular, others oblong. Usually there is a prominence near the center, called the nipple of the scale. The scale of the adult consists of the successive exuviæ which have been shed by the young in its transformation. Only the adult females are found beneath the scale. They are legless, wingless, rounded masses, with no eyes. Their mouth parts consist of a very fine filament composed of three parts. This is inserted into the substance of the leaf or through the bark, and by this means the insect obtains her nourishment. Once fixed in a certain spot upon the food plant, she never moves, and probably never removes her proboscis from the place where it is first inserted. She lays her eggs under the scale, and the young come forth from beneath it to begin their own independent existences. The hinder end of the female's body is composed of a series of what are called anal plates. These are portions of chitin—the hard material found in the walls of all insects' bodies. They are lobed, and between the lobes are arranged series of bristles or spines. The form, number, and position of these plates are characters upon which are based the classification of these microscopic insects. Very frequently the food plant of the scale is used as an aid in its determination, but this is variable, as there are certain scales like the San Jose (*Aspidiotus perniciosus* Comst.) and the oyster shell bark louse (*Mytilaspis pomorum* Bouché), which have a variety of food plants. The male larvæ of the insect forms a scale, as does the female; but when it reaches the adult stage it comes forth a winged insect, similar in appearance to the one shown on Pl. I, fig. 6. A young scale insect, with its legs and other parts of the body complete, is shown on Pl. I, fig. 4. At certain seasons these minute insects may be seen crawling around upon the infested leaves or twigs, but they soon settle, usually within a few days.

It is impossible to observe or attempt to study this class of insects without the aid of a fairly good hand magnifying glass. They are so small and so little resemble insects as we usually know them that they would scarcely be taken for such by persons not familiar with the subject. For this reason they are enabled to gain a good foothold and to multiply to very great numbers unless checked by some natural enemy. In connection with the question of their multiplication, it may be said that these insects, like Aphids, multiply with very great rapidity and in numbers which are simply astonishing to those not familiar with their habits and life history. It is claimed that a single pair of the San Jose scale "will in the course of a summer in the United States become the progenitors of more that three billion offspring." Thus the cacao which might be slightly infested with scale at one time might very shortly thereafter be completely covered.

The first of the scale insects found upon the cacao, the sisi scale, so named from its resemblance to a Filipino oyster, so called in Visayan, is black, shiny, and has the shape shown in fig. 190. It has thus far been found only upon the upper side of the leaf near the midrib. It is very slightly convex. Upon reversing the leaf a yellowish spot can be seen beneath where the scale is lying. This is caused by injury to the leaf tissue—a result of the insertion of the insect's proboscis.

The combating of scale insects has presented one of the most serious problems which has confronted not only the grower of fruit and other trees, but also the economic entomologist, during the past few years. All kinds of remedies have been tried, such as kerosene, crude petroleum, whale oil soap, hydrocyanic acid gas, lime, sulphur, and salt mixture, as well as patent articles, all of which contain some one or more of the above ingredients. Even now it is extremely difficult to say with any certainty which of these remedies or whether any of them will prove best adapted to the needs of the cacao grower who finds his trees threatened by this evil. No experiments have thus far been made anywhere in the Philippines with this class of insecticides with reference to the treatment of the scale insect, owing to the lack of the proper materials and of the machinery for their application, and also to lack of opportunity, thus far to devote to this very interesting and important subject.

Many plants in the Philippines, as elsewhere, are attacked upon their leaves, branches, and fruit by several species of insects known as the mealy bug. These belong to the same family as the scale insects, the Coccidæ, and their effects upon the cacao are only second in importance to the work of the cacao borers.

Going through a cacao grove at the time that the trees are in fruit, one notices many pods which bear a whitish fungus-like material. Upon closer examination the fungus-like growth will be seen to consist of large masses of whitish insects. These are 3 mm. long and 2.35 mm. broad, and the bodies, which are pinkish yellow, are covered with a fine powder-like substance. If examined with a magnifying glass, it will be seen that this powder extends only to the sutures or joints of the segments, and that the latter may be readily counted even in those individuals which have much of the powder. These bugs attack the fruit just after it has set and, multiplying thereon with great rapidity, often cover it entirely by the time it is ripe. They begin first in the depression or grooves and gradually spread upward upon the lobes of the pod. They crowd together in large numbers and are invariably attended by swarms of ants, whose purpose is to secure the honeydew voided by them. One of the most interesting examples of the interdependence of insects is shown in the relation of the ants to these plant lice. Upon certain pods it is not an uncommon sight to see the valleys between the lobes of the pods completely roofed over by a gray material, which upon examination proves to be a kind of crude paper formed from particles of the decayed wood of the cacao tree. Small black ants will be seen running in and out through the openings in these sheds, and curiosity upon the part of the observer leads him to break away a portion of this material in order to find out what, if anything, is beneath it. He is rewarded by finding in the grooves thus protected large numbers of the white mealy bugs, with their young and with willing servants, the black ants, attending and caring for them. The ants will be seen taking individual mealy bugs in their jaws and carrying them from place to place, and especially is this true of those that are exposed to view by the destruction of their roofs. The bugs submit to this with no sign of displeasure. If the observer watch long enough, he will see the ants building the roof or repairing the parts which have been broken away. They manifest great uneasiness when disturbed, and all those individuals which are under the roof at the moment come forth and assume an aggressive attitude, sitting up on four of their legs, with the front ones in the air and the abdomen doubled under, as if about to sting. They, however, possess no sting and only assume this attitude in instinctive imitation of those forms that do possess one.

The author has found cacao pods upon which all of the ten grooves were completely filled with the mealy bugs and roofed over by the ants. A unique feature of the fruit thus attacked was that one of the tunnels extended to the fruit stem and along the limb to the tree, and then down the trunk to a spot where the ants entered a part of the tree which was decayed. Upon opening this decayed wood the true nest of the ants, with their young in all stages, was found. This would seem to indicate that the tunnels or roofs are not built solely for the benefit of the mealy bugs, but also as a protection for the ants in going back and forth from their nests to the pods, where their "cows," as they are sometimes called, live. This double and somewhat intricate system shows in a way the wonderful provision of nature whereby through their interrelationship certain species of insects are propagated and perpetuated. It is undoubtedly true that without this provision either one or the other of the species would soon be exterminated. In as far as these animals are related to man and to his economy they must both be considered enemies—the mealy bug in being directly injurious to the product of the cacao and the ant indirectly as protecting and caring for the mealy bug in order to secure the product of its attack upon the tree. The latter must, therefore, share with the former in any treatment looking to its extermination.

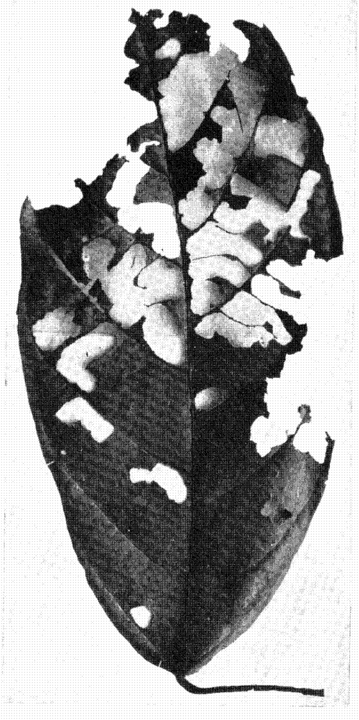
Little is so far known of the life history of this cacao mealy bug. Its eggs have been discovered in alcoholic material and the young have been found in great abundance in the deeper grooves of the cacao pod. (In Plate I is shown a ripe cacao pod upon which are represented the adult and young mealy bugs with the tunnels or sheds built by the ants. The openings of these sheds are regularly constructed, so that the ants can go in and out at certain places without disturbing the bugs.) By whatever method these insects are treated the sheds would offer but little, if any, hindrance to the effect of the insecticide, inasmuch as they are built of an extremely porous material, through which kerosene, crude petroleum, or other similar material would soak very readily. Probably the very best solution to apply to these insects would be the kerosene emulsion recommended for plant lice. Their bodies are fully as tender and delicate as those of the plant lice, and therefore the same proportions of ingredients could be used. The sheds where they were present would hold the insecticide longer in contact with the insect's bodies, and would thus be a help in the extermination of the mealy bugs. Naturally the best time to spray the trees for these insects is just after the fruit has attained the size of a small hen's egg. If successfully subdued at this time the chances are that they will not reappear.

The amount of injury these insects inflict is shown in the smaller size of the pods attacked by them, the scars which extend down into the fiber of the pods, and the general inferiority in size and quality of the beans or kernels themselves. Pods infected by these bugs are not only inferior in quality to those unaffected, but they are also very unsightly to those who have to handle and open them. I am thoroughly convinced that with proper care and judicious use of the spray pump and kerosene emulsion of a proper strength these minute pests may be entirely eradicated from the cacao grove, and clean, healthy, well-filled pods will be produced where now inferior ones exist.

There is another species very similar to the mealy bug, which has been found upon the cacao in a few instances. It is also quite prevalent upon the "Nangka" (*Artocarpus integrifolia* Linn.), covering the fruit stem and often the small twigs. It is covered with a thin white or yellowish-white incrustation, which breaks very readily upon being touched, however lightly. As this insect has been found only in a few instances, and on trees which were in close proximity to Nangka, it is probable that it will not naturally attack the cacao. However, it would be well to be on the lookout for it. Further observation will reveal the facts with regard to its preference for cacao, and its life history and habits may then be discussed at greater length.

There are few trees which have a host of enemies without at least a proportionate number of friends in the insect world, and the cacao is no exception to this rule. In many cases the insects, which in some way or another prove beneficial to the cacao, are not found solely upon this tree. This does not have reference to the parasites of the insects which affect the cacao, but includes such insects as wasps, aphis-lions, ant-lions, and spiders, the latter not being insects in the technical sense.

Among wasps which are found upon the cacao, and which are known to feed upon larvæ and adults of noxious insects, may be mentioned the "Alingayo" and the amomo-ong, called here by their Visayan names. The former belongs to the true wasp family, the Vespidæ, and the latter more strictly to the hornets. The alingayo, which is familiar to all who live in the Visayas because of its very sharp and severe sting and the fact that it often builds its nest in houses, is not more than 13 mm. in length. It is of a light-brown color with transverse bands of yellow upon the abdomen and diagonal ones upon the thorax. The second segment of the abdomen is as long as all the other segments together, and when at rest the insect retracts the hinder segments within this long one, giving it a very short, stubby appearance; but when angered and about to sting it can increase the length of the abdomen more than twice its normal length. A broad band of yellow borders the hinder edges of the second abdominal segment, which is of a deeper brown than the rest of the body. The stinging instrument is very sharp and about 2 mm. long, curving slightly downward. The eyes are slightly yellowish, the antennæ are broken or jointed at a distance from the head of about one-third of the entire length and they droop forward in front of the eyes. When at rest this insect folds its two pairs of wings down between the thorax and abdomen, and thus they lie for a part of their length below the abdomen, as shown in fig. 191*d*. The general appearance of the insect is given in the same figure at *b*. This insect builds a nest like the one shown at fig. 192. It is often as large as a man's two hands and every cell contains a grub or a pupa. The larvæ are fat, legless grubs, with no sign of eyes or other appendages and they feed upon the masticated and partly digested insects which the adult brings to them. Fig. 191*b* shows the full grown grub and fig. 191*c* the pupa, which has been removed from its cell and from the delicate silken cocoon which was spun before its trans-



WORK OF BEETLE, SHOWN IN FIG. 188.

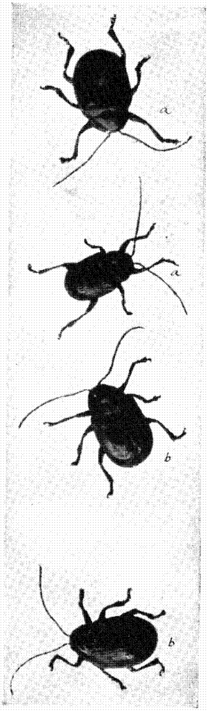


FIG. 188.

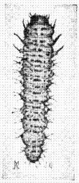


FIG. 189.

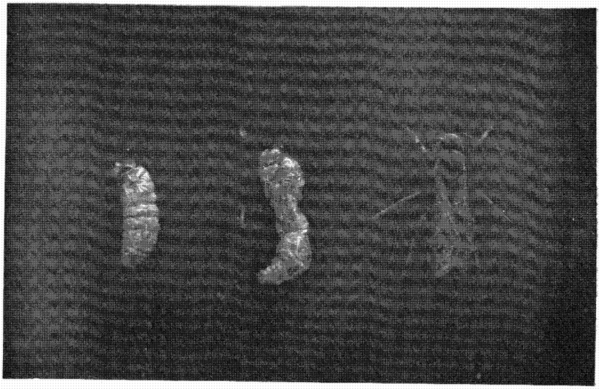


FIG. 191 *a*, *b*, *c*.

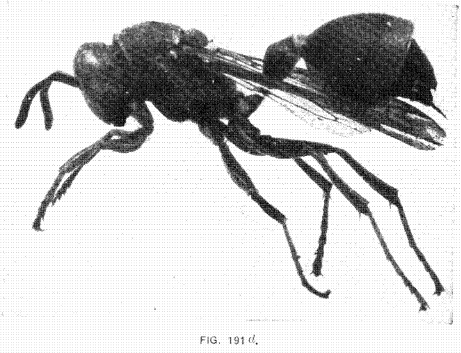


FIG. 191 *d*.

formation. Soon after changing to the pupal form the insect is a creamy white, but as the process of development goes on it assumes a darker color, beginning at the eyes, which are the first to show evidence of the true color of the perfect insect.

These insects have been seen to capture small caterpillars, and gradually chew them up into a soft mass, which they carry in their jaws to their nests. They feed upon other insects and do not disdain flies. It is estimated that a colony of 100 of adults will destroy in a month more than 3,000 caterpillars and other insects. Fig. 191 shows the larva, pupa, and adult of this interesting and useful little insect.

The amomo-ong is very much larger than the alingayo, and is one of the most beautiful wasps that I have ever seen. It is 30 mm. long and 7 mm. wide, of a jet black, with three transverse bands of orange red, one on the upper part of each of the first three abdominal segments, the second being about thrice the width of the first and third. The head and thorax are of a dull velvety black. The compound eyes are black and glossy, and in the top of the head are three little black glistening ocelli or simple eyes, forming a triangle. The wings of this beautiful insect are of a reddish brown, the fore wings measuring 23 mm. in length. They are somewhat smoky. They extend just to the tip of the abdomen. The antennæ are elbowed as with the alingayo and droop over the eyes. The legs and feet are of a color uniform with the body, and are provided with claws for grasping the surface upon which the insect rests, and for obtaining its prey. These insects have the same habits as the alingayo, but instead of building a flat nest with all the cells in the same plane, their nest has the appearance shown in fig. 193, which shows also the adult. With this nest were captured some eight adults, about half those present. These insects are valiant protectors of their homes and their young. They will remain in the nest even when struck at with poles, one or two of them darting at the intruder. When the nest has been torn away they will even come back to the same spot and attempt to build another in its place. This is contrary to the usual habits among insects, of giving up a place when once their nest is damaged or destroyed. That these insects render a valuable service in the destruction of larvæ of injurious species is beyond question of doubt. They have been repeatedly caught when returning to their nests with full grown larvæ in their claws. They carry their prey in their claws rather than in their jaws, as is the case with the alingayo, and they do not masticate it until they reach their nests.

Among the species of caterpillars which have been taken away from these wasps are those of Geometridæ, Lymantriidæ, Cetonia, and Tortricidæ in large numbers.

In all cases where not so numerous as to prove annoying by stinging unsuspecting workers among the trees, they should be left alone in their nests. Another insect which is frequently met with upon the cacao tree, and which might be mistaken for its enemy, is one of the true bugs, a Reduviid, which I propose to call the "red corsair." This Hemipteron belongs to a class of insects which are very properly called assassin-bugs, because their instinct is directed to the killing of other insects. The red corsair, a picture of which is shown at fig. 194*a*, is a very showy insect, having a black underbody with red thorax and red wings. The head and feet are black, as are the antennæ. The insect measures 17 mm. long and 5 mm. wide. The head, which is very long and narrow, has a peculiar beak which curves under toward the thorax. This is very sharp and is used for sucking the blood of insects which the red corsair captures. (Fig. 194 shows a dorsal view of the insect, while at 194*a* it is shown with the head and beak much enlarged.) The nature of the beak can be readily seen from the drawing.

This insect moves very stealthily about upon the surface of the leaf and pounces upon whatever insect it may find. It has been observed most frequently feeding upon geometrid caterpillars, which it holds between its fore feet while sucking their blood. When not seeking its prey it rests quietly with its legs spread far apart and the body suspended above the surface upon which it is standing.

If caught in the fingers this insect is liable to inflict a sting with its beak, which, while not poisonous, is very painful, to say the least, and with some persons this may result in a painful swelling. They do not, however, need to be handled, and the good they do on the trees in the matter of destroying noxious insects is of incalculable value when compared with the occasional bites they may inflict on those who carelessly handle them. Their eggs are laid in crevices of the bark, and when the young come forth they look very much like the adults, save that they have no wings. The young also feed upon small larvæ and other insects. Stål, in his "Hemiptera Insularum Philippinarum," calls this insect *Sphodronyttus erythropterus* Burm., var. *convivus* Stål.

In a cacao plantation in which the top soil is sandy, and in which there has been no rain for some time, one will very frequently see around the bases of the trees a number of cone-shaped pits with the sides, which are composed of loose sand thrown at an angle of about 45° to the surface of the ground, coming to a point below. If an ant or a fly be tied to a string and let down into the bottom of this pit it will be at once seized by a pair of jaws which is lying concealed in the sand. If the observer be quick enough he may succeed in jerking out a peculiar looking gray insect resembling a large-sized louse and, in fact, so called by the Visayans, who name it cotu-cotu, meaning a big louse. This animal, which measures when fully grown 12 mm. long and 5 mm. wide, is the larva of a very delicate and beautiful insect of the family Myrmeldonidæ of the order Neuroptera. The adult measures about 29 mm. in length and has an expanse of wings of about 60 mm. The wings are irridescent and the general color of the insect's body is a smoky gray. The eyes are rather large and spherical, being prominently set, like those of the damsel flies, relatives of the dragon flies, or, as they are called in Visayan, tumbuc tumbuc. One would never associate this delicate insect with the voracious cotu-cotu.

The larva has habits which are as strange and incongruous as its appearance. Its two forcep-like jaws are adapted solely to sucking the blood of unfortunate insects which drop into the pit which it has dug for them. It invariably moves backward instead of forward. If dropped upon a sandy spot it almost instantly disappears. It uses its tail end as a sort of shovel to dig its way into the ground. Its method of constructing its pit is interesting in the extreme. After working its way below the surface it begins to move around in a circle, the diameter of which is in proportion to the size of the insect and consequently in proportion to the hole which it will finally have excavated. When it has completed its circle it begins throwing out the sand with its head, which serves as a shovel. As the sand is thrown out the larva gradually moves toward the center of the pit, which, from the force of the caving sand on the sides, begins to assume a conical shape. When the ant-lion, for such it is called in English, encounters a pebble or small stone it immediately lifts it upon its opened jaws and attempts to throw it out. It can throw out a stone which weighs much more than its body. When the pit is completed the ant-lion goes into the sand at the apex of the cone-shaped hole and with only its jaws and its eyes protruding it awaits the coming of some unwary insect. It usually has not long to wait, for, as a rule, ants and such crawlers are very curious when they come to a hole. They invariably like to investigate, and peering over the edge of this pit they lose their balance and begin to slide down. Their downward motion is very much accelerated by the action on the part of the ant-lion, which immediately begins to throw sand up over them; this takes the sand away from under their feet and in a shower of the material they are gradually forced back down into the pit. Finally reaching the bottom completely exhausted, they are seized upon by the skillful foe, dragged under the sand and their blood sucked out. Afterwards their dried skins are flung out of the pit by the ant-lion. (Fig. 195 shows two views of the ant-lion's nest, one being sectional, with the insect seen at the bottom. Fig. 195*a* is the larva.)

The ant-lion will not attack large insects like beetles or big spiders, which occasionally fall into its pit, but remains quiet until the intruder can get out. It will attack the termite, any kind of ant, small flies and bugs, and it has been seen to drag small moths under the sand. When ready to pupate, the ant-lion spins a spherical cocoon of grains of sand fastened together by a beautiful pearly white silk, with which it is also lined.

This insect can certainly be called a decidedly beneficial one, for of all the insects which it has ever been seen to take, not a single one was other than noxious, and the number of ants and anay which it captures and kills in course of its somewhat lengthy larval stage must be great indeed.

To the Orthopterous family Mantidæ belong several very peculiar-looking animals which have received the attention of even the most careless observers from time immemorial. They are called mantis, devil's riding horse, camel horse, mule killer, etc., in English and tagat-tagat in Visaya. In Tagalog they are known as Sa-sambá. Unlike most Orthoptera they are carnivorous, living upon other insects and are therefore to be classed as beneficial.

They lay their eggs upon the twigs of the cacao and other plants, and as many as 200 of the young hatch from an egg mass such as is shown by fig. 196. The young are very much like the adults in appearance. (Fig. 197 shows a young mantis and fig. 198 an adult.) The fore legs are fitted for grasping the prey. They often remain motionless upon a twig for several hours, but if an insect comes within reach they immediately, with great rapidity, grasp it in their forefeet and proceed to eat it, only rejecting the harder parts and the wings. After feeding they very neatly clean their faces, antennæ, and front feet, and again begin their watch. They run readily and are also good fliers. They rest entirely upon the two hinder pairs of feet. They have the habit of sitting up and watching the observer, who in turn becomes the observed. The large eyes and peculiarly shaped head, together with the large body, make them objects of very grotesque appearance.

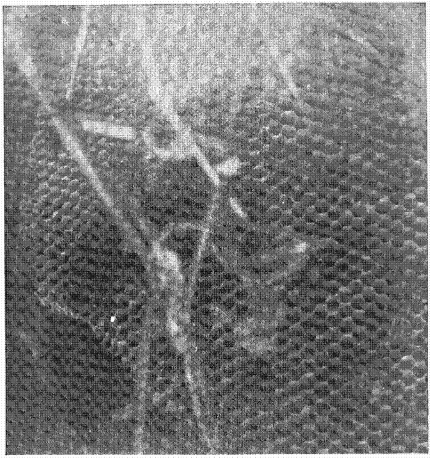


FIG. 192.

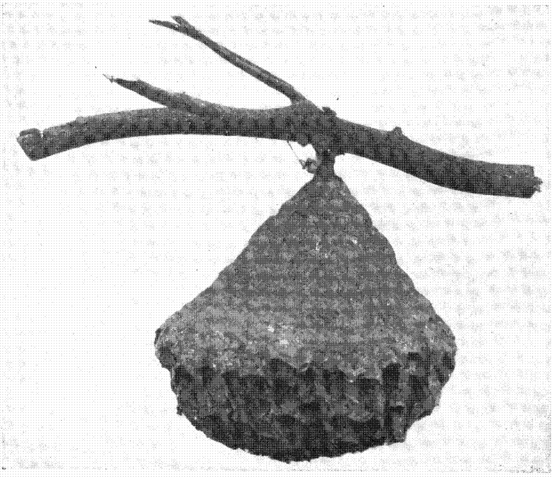


FIG. 193.

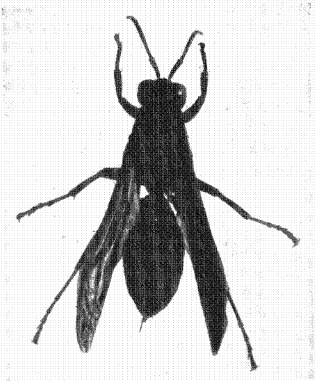


FIG. 193.

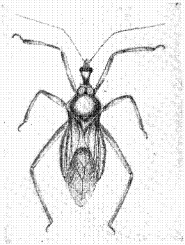


FIG. 194.

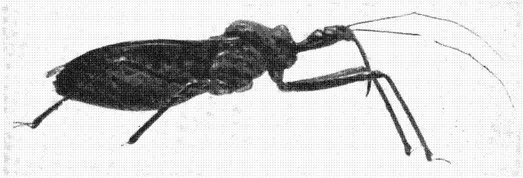


FIG. 194 *a*.

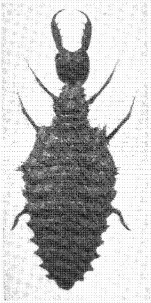


FIG. 195 (DORSAL VIEW).

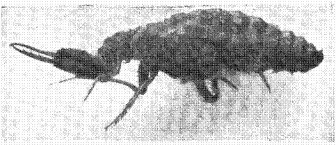


FIG. 195 *a*.

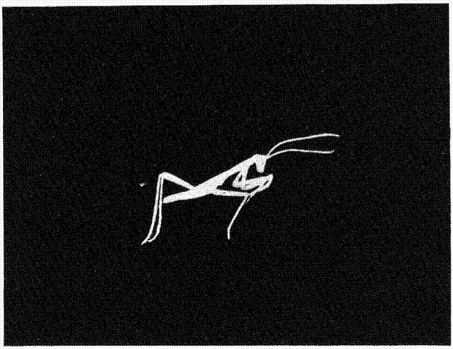


FIG. 197.

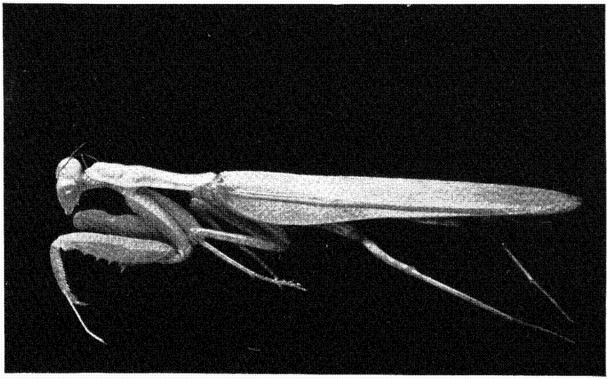


FIG. 198.

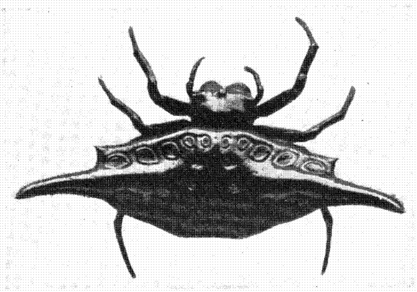


FIG. 199.

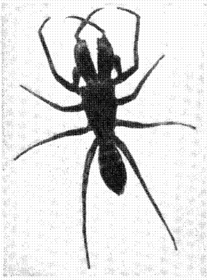


FIG. 200.

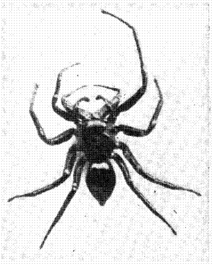


FIG. 200*b*.

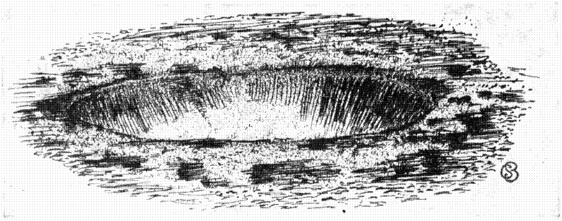


FIG. 195 *a*.

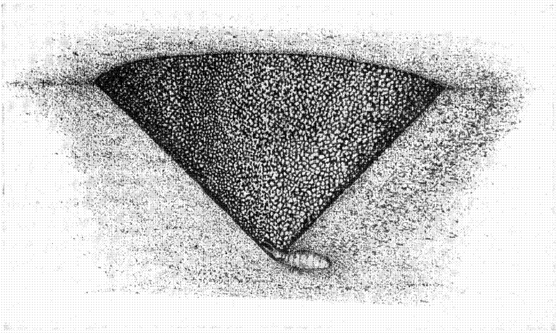


FIG. 195 *b*.

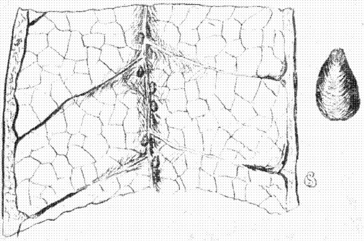


FIG. 190 (ORIGINAL).

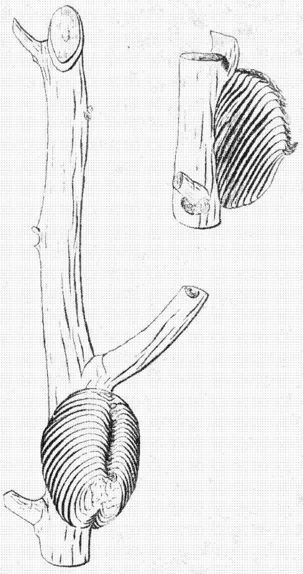


FIG. 196.

The large spiders which live upon the cacao and which undoubtedly do it a service by the number of insects which they capture and devour, renders them the subject of special attention, although they do not come under the technical classification of insects.

Among those which have been found most abundantly are the orb weavers, the jumpers, one species of tarantula, and many species of crab spider or Thomisidæ. Perhaps the most peculiar, and one of the most beautiful of the orb weavers, is the crescent spider, which is illustrated by fig. 199. It has the abdomen shaped in the form of a perfect crescent, and is of a beautiful jet black and yellow, and the horns at the sides of the abdomen are pubescent at their tips. This spider builds a true orb web and catches many insects, the most of which are harmful to the plant. Among these have been noted plant lice, moths, plant bugs, and small Coleoptera, like Scolytidæ, Chrysomelidæ, and Scarabacidæ, all harmful classes.

The crab spiders are so called because of their resemblance to crabs in form and arrangement of the legs. They are of a light color, usually like the flowers which they inhabit, and lie concealed in the clusters. They seize plant lice and other small insects as they come to the flowers. Undoubtedly they occasionally capture beneficial insects like hymenopterous parasites.

The majority of spiders found upon the cacao belong to the jumpers or Attidæ. These spiders are sure to attract the attention of the observer because of their peculiarly beautiful and varied colorings and their activity. They are light green, golden yellow, brown and red, black, gray and of many other and striking colors. They are extremely active, jumping forward or backward or sidewise with equal celerity, and they invariably capture their prey by pouncing upon it. Their eyes glow with what appears to be internal fire and their position on the head and their form suggest in a most remarkable way the headlights on an automobile.

A most peculiar and common form of the Attidæ are the ant-like jumpers. They vary in length from 3 to 10 mm., according to the species, and their resemblance to black ants is so very close, not only in form but in their movements, that they often deceive the close observer. They run upon only six legs, carrying the two fore legs high in the air and moving them with the same uncertain motion that ants use when moving their antennae. They will run a short way, then stop and wave their front feet, then start off sidewise, then back up, and, before one knows what they will do next, have pounced upon some unsuspecting fly or bug. In form of body and movements they really represent one of the most striking cases of mimicry. (Fig. 200 shows examples of the ordinary jumping spider and the ant-like form.)

At the base of the cacao one frequently sees a hole 15–20 mm. in diameter, carefully and neatly lined with snowy white silk, which sometimes extends out upon the ground for some little distance. If one will dig out this hole, following its twists and turns at the inner end, which is usually 40 or 50 cm. in the ground and parallel with the surface, if the ground be level or horizontal, if the hole be in the side of a hill or mound around the tree, he will be almost sure to find a most beautiful dark brown hairy spider of the tarantula family, Theraphoridæ. This spider measures when extended, including legs, 85 mm. long and 65 mm. broad. Its brown velvety coat is almost black when it is seen curled up against the white background of its silken cell. If one of these spiders be examined after being killed it will be seen to have two very strong, curved, brown, forcep-like mandibles which, instead of approximating point to point as in most spiders, are bent forward and downward so that the tarantula can not really grasp its prey with its jaws. It is, however, provided with two foot-like palpi which serve to hold its food while it is being eaten. These palpi give the tarantula the appearance of having 10 legs instead of the true number which all spiders have, namely, eight.

The area around the mouth is covered with golden reddish hairs. This characteristic seems to be common to most of the tarantula family. The spider feeds upon most kinds of insects; the exuviæ of several larvæ and pupæ being found in some of the nests opened. It seems to show a great preference for cockroaches, several of their skeletons having been found in its abode.

A word should be said before concluding this paper regarding some other animal pests of the cacao. In all parts of the world great trouble has always been experienced in cacao growing because of the ravages of rats and mice. These little rodents, working at night, often do an incalculable damage to the fruits, destroying many pounds of the nuts in a season. (Fig. 201 shows cacao pods, each with a hole in the side just large enough for the small rodent to enter.) It very skillfully removes all the kernels from a pod and leaves it hanging on the tree, where it dries if not removed by the grower.

No effective remedy has been devised for this pest, but the writer would suggest that an excellent one can be found in the discarded pods after the ripe nuts have been removed. The pulp on the inner side of the pod being scraped out and mixed

with some kind of effective poison, like arsenic or paris green, is replaced in
quantities in each pod. The pods are to be then fastened together with two ba
toothpicks and the decoys placed beneath the trees, two or three under each.
more than likely that the rats, finding these upon the ground, will attack them
and gnawing into them will eat the sweet pulp within. The results will then r
to be seen, but certainly the chances of success are very much in favor of the gro
All hogs and other domestic animals should be excluded from plantations in
these experiments are being tried, and the refuse should be collected as soo
is seen that the pods have been gnawed into by the rats, and buried at a suf
depth to insure its not being dug up by hogs. As the pods are liable to shrive
open during dry weather, they should be renewed from time to time as occasio
require.

Very little can be said at present concerning insects attacking the dried prod
the cacao, namely, the beans and husks. In visiting various wholesale esta
ments for the handling of cacao in Manila, beans have been found giving evi
of the work of some form of the common dried fruit moths, but thus far neith
larvæ nor the adults have been discovered.

Chittenden in his bulletin on [a] "Some Little-Known Insects Affecting Store
etable Products," says the following in connection with a moth which he ca
chocolate moth. I would, however, suggest that instead of being called the "c
late" moth it be called the cacao bean moth, as it is more frequently found
bean than in the manufatured chocolate.

"The habits of our flour and meal-feeding *phycitids*, *Ephestia Kuehisella* and
interpunctella, are so well known as to necessitate no further comment here, but
is still a fourth moth which, although represented in our faunal lists, seems ne
have received mention as an injurious species in this country. I refer to *E*
elutella Hbn. Its habits have been known in Europe since early in the last ce
yet so far as I know at present American records show nothing positive reg
injuries.

"Reaumer's account of the moth that injures chocolate, published in 1737, is
ally conceded to refer to the present species and as it is this species that is most
associated with the chocolate nut of commerce it may be called the chocolate
Recent study of bred material shows this to be the moth mentioned in Inse
(Vol. IV, p. 332) as having been received at this office from Mr. H. F. Wic
who found it injurious to cayenne pepper in one of the drug houses at Iowa
Iowa. We have also specimens bred from dried apples obtained from a New
City dealer and submitted to this office by the Division of Chemistry, and other
cacao beans received from Mr. C. A. Barber, who obtained them from Monts
West Indies. According to various European authorities, this species also a
manufactured chocolate, coffee, and various dried fruits, and even does consid
damage to ship biscuit, which it injures after the manner of *E. kuehniella*."

It may prove that the above-mentioned species is the one which has been
in the cacao in Manila and the possibility is more strongly emphasized by t
that the condition of the beans, the class of holes made, and the frass con
within the beans, all point to the work as that of a *Phycitid*.

Certain beetles of the families Tenebrionidæ, cadellus or darkling beetles, a
Nitidulidæ or sap beetles, are also found in stored vegetable products as wel
decaying or overripe fruits and on wounds in trees, the sap of which they
For these insects, as for all others which are found in stored products, it is d
to suggest an effective preventive, inasmuch as the pests find such ready me
entrance through the meshes of the sacks. Even where the adult insects ca
themselves get into the bags and sacks, instinct seems to lead them to lay the
upon the outside and the tiny larva upon hatching find easy ingress. Once
the insect passes through its transformations, but upon becoming adult it ca
escape and continues to multiply.

Frequent handling of the contained cacao and a careful shaking of the bags,
wards placing them in bright sunshine, renders the cacao less liable to be at
by any form of insect which would eat the dried nut.

Where prevention has failed, or where infested cacao is received by the deal
best plan is to submit the full sacks or, better, the contents, if possible, to the
of carbon bisulphide in a closed bin or other absolutely tight receptacle. If
tight room can be had, the sacks may be left in it for two or three days or even
without any harm being done to the beans, and with the perfect assurance t
insects contained therein will be exterminated. At the end of that time t
or room should be opened and thoroughly aired and the cacao spread out in
or in the sunlight.

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[a] Bul. No. 8, N. S., U. S. Dept. Agr., Div. Ent.

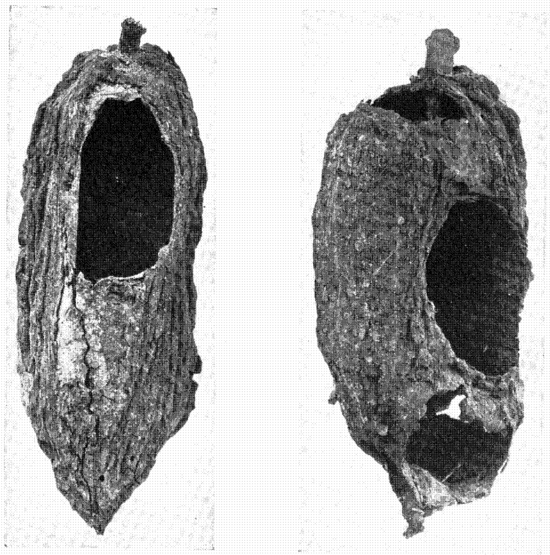


FIG. 201.

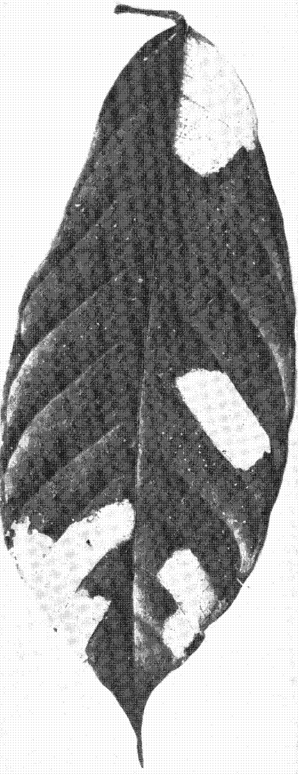


FIG. 202.

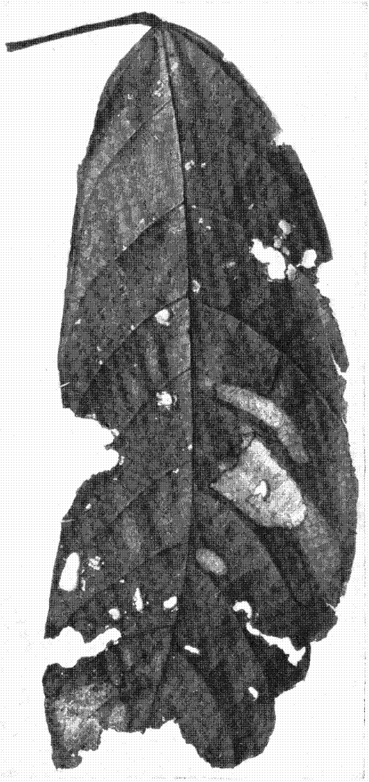


FIG. 202.

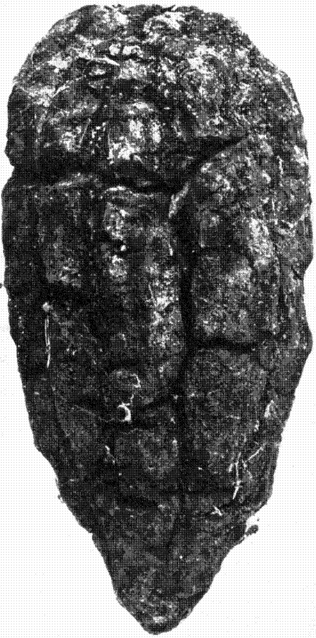


FIG. 203.

Under no conditions should a lamp or other light be permitted in a room where the carbon bisulphide is being used nor should persons remain in the room. If a bin be used, the bisulphide may be put on top of the cacao in a small dish, allowing 30 to 40 grams for every cubic meter of space. As the bisulphide is heavier than the air and very volatile, it will evaporate quickly and settle downward in the bin, suffocating all insects therein. If a room be used, the vessel may be put upon a high shelf or upon some object so that it will be as near the ceiling as possible. In this way the entire room will be fumigated.

Although the question of plant diseases like fungi, rust spots, mold, and rot do not belong to the province of the entomologist to investigate, the fact that these diseases were given some attention by him during his investigation of cacao insects will warrant a few words being said upon them and suggestions being made for their prevention upon the leaves and fruit of this valuable plant.

There are four types of fungous attack which have been most frequently met with, namely: Cacao leaf spot, cacao leaf blight, cacao pod spot, and pod scab. The first of these diseases attacks the leaf in spots as suggested by the name. (See fig. 202.) These spots are irregular in shape and in an advanced stage are a dull, whitish gray, as though the leaf had been scorched to an ash at the point, which dries and breaks off as if the leaf had been held in the fire. The type of fungus disease which attacks the pod is very characteristic, and will be recognized by the growers at once as that represented in fig. 203. Both of these attack the fruit in all stages of its growth. The pod spot occurs in spots similar to that which attacks bean pods in the United States. The spots soon completely cover the affected pod and not only cause a very unsightly growth, but also materially affect the development of the fruit. Fruits which are thus affected are smaller and the beans are found to be misshapen and in some cases not developed. The history of this disease, its causes and morphology, are yet to be investigated.

The pod scab is undoubtedly the worst form of disease which attacks the cacao. It is recognized in its advanced stages by the fact that the pod becomes dry, either upon one side or over its whole surface. It then cracks open in unsightly gashes as though hacked with a knife. Of course, the contained beans in such pods are worthless. There is another disease of which the causes are not clearly known.

Although diversified in their modes of attack, it is undoubtedly true that the same means of prevention will apply to them all since they are fungoid or bacteriological in character. Many thorough tests, covering a period of several years, have demonstrated the efficiency of a mixture of copper sulphate (blue vitriol) and quicklime, commonly called Bordeaux mixture, for nearly all kinds of fungus diseases affecting plants. The blue vitriol is the fungicide or destroyer of the fungus spores and the lime is added to keep the vitriol from burning or scorching the leaves or fruit. This solution, a formula for which will be given under insecticides and fungicides, will of course, have to be applied to the trees by means of spray pumps and a very fine spraying nozzle.

The writer is well aware of the fact that in the limited time during which he has studied the questions of insects and diseases of the cacao, many forms and conditions have escaped his notice, but as this is only a preliminary bulletin and issued so that the grower may have something at hand to guide him in the recognition of and dealing with the most important pests, the fact that all pests are not treated will not detract from its usefulness. He would be under great obligations to all growers of cacao to whom this bulletin shall come if they will send him suggestions of methods which they have tried with success.

There is a disease called "die back," mentioned by Mr. Lyon in his bulletin on cacao, which I have not found in the Philippines, and he would be grateful for specimens showing this disease.

The production of cacao has such a favorable future in these islands that any measures which will tend to a better degree of cultivation, and a more thorough protection of trees from unnecessary ravages, should be welcomed by growers and prospective growers throughout the Archipelago.

SOME INSECTICIDES AND FUNGICIDES; THEIR USE AND PREPARATION.

Insecticides and fungicides have for their object the prevention of the attacks of insects or fungus diseases, or the killing of forms already present either upon the plant or other substance affected by the insect or the disease.

With reference to insects, there are two kinds of insecticides, the internal and the contact. Of the latter there are the corrosive poisons, which attack the substance with which they come in contact, and the suffocating poisons, which act upon the breathing apparatus, producing suffocation. Among the most important of the internal poisons are those which have as a basis some form of arsenic. This substance in any form is deadly to all animal life. As there are many forms of arsenical insecticides, only those which are considered as of value in connection with combating of cacao insects will be mentioned.

Internal poisons are those which are intended for the insects which eat the substance of the leaf or other part of the plant. Applied to the surface of the leaf, either as a powder or as a solution, it is taken by the insect along with its food, and, acting upon the alimentary canal and other internal organs, accomplishes its work.

Contact insecticides are those which coming in contact with the body of the insect produce a condition, usually of the nature of a corrosive, which results in death. To this class belong ashes, lime, kerosene, carbolic acid, crude petroleum, pyrethrum, and smoke.

Suffocating poisons are those which, entering the tracheæ, either clog them up or paralyze the muscles of respiration, thus killing the insect. To this class belong carbon, bisulphide, naphthaline, benzine, petroleum, kerosene, whale-oil soap, and the fumes of hydrocyanic acid gas.

Arsenate of lead.—This insoluble chemical compound is prepared as follows:

	Grams.
Lead acetate	200
Sodium arsenate	50

Dissolve each ingredient in 16 liters of water, separtely, in wooden or stone vessels. Then pour these at the same time into a barrel or tank containing 450 liters of water. The mixture should be stirred constantly and rapidly while making. Inasmuch as the compound which is formed (arsenate of lead) is insoluble, it is precipitated as a white powder and must be kept in suspension. In order to make this mixture stick well on the foliage to which it is applied, about 2½ liters of glucose or grape sugar are added to it before spraying.

Paris green.—This is an acetic-arsenite of copper and contains from 55 to 60 per cent of arsenious acid. It is a bright-green powder, very heavy, and hence does not stay suspended in the water of a spray pump unless continually agitated. As it does not dissolve in water it will, when pure, not "burn" the foliage of even the most delicate plants. If, however, twice the amount of freshly slacked lime be added with a given quantity of Paris green, all danger from free arsenic will be averted, and there will be no danger of "burning."

Paris green would undoubtedly prove an excellent poison for mice if applied mixed with meal or bran and the pulp of the cacao. The proportion should be 1 part of the Paris green to 50 parts of meal or bran.

In using Paris green as a liquid insecticide it is applied as follows:

Paris green	grams	450
Lime (fresh slacked)	do	900
Water	liters	1,500

This is a cheap insecticide, is in universal use, and if care is used to keep it in suspension in the water while spraying, it will give as good results as any of its class.

Numerous other arsenates are sold under the following names and others: White arsenate, pink arsenate, white arsenoid, parine green, laurel green, London purple, paragrene, and green arsenoid.

Kerosene.—This is a refined product of petroleum which is so well known as to render a description unnecessary. Applied pure to any kind of insect it immediately destroys life. It is likewise fatal to plant life if undiluted. Used in a mechanical mixture with water it is a remedy against scale insects and plant lice. A safer and much more effective preparation is the kerosene-soap emulsion, which is prepared as follows:

	Per cent.
Kerosene (9 liters)	67
Common or whale-oil soap (225 grams)	33
Water (4.5 liters)	

Heat the solution of soap and water and add it, boiling hot, to the kerosene. Churn the mixture by means of a force pump and spray nozzle for five or ten minutes. The emulsion, if perfect, forms a cream, which thickens on cooling, and should adhere without oiliness to the surface of glass. The above formula gives 12.25 liters, and makes, when diluted, 120 liters of wash. (Report of the Entomologist: in Report of the Comr. of Agr. (U. S.) for 1883, p. 152.) Another formula which may be of interest is the following, taken from Dr. J. A. Lintner's Second New York Report on Inj. Ins., 1885:

"Eight parts of water and one part of soft soap, thoroughly amalgamated, forms the lye, which takes mineral oil and thoroughly mixes with whatever proportions of the oil be added. As heat aids much in quickly producing thorough amalgamation of the ingredients, boil the soap and water together, and, when ready, turn into ordinary wine bottles (costing little or nothing, especially in the Philippines), which have been placed in boiling water. About half fill the bottles, turn 125 c. c. of the oil into each bottle, then fill up with the boiling lye. Cork at once and store away for use.

"When required for use, a bottle of the mixture is poured into an 18-liter watering pot which is filled up with soft water and is ready for use, at a strength of 70 c. c. to 4½ liters of water (1 part oil to 64 parts of water in about 1⅔ per cent). Seventy cubic centimeters of oil to 4½ liters of water is strong enough to kill Aphides (the plant lice in question), and such soft-bodied insects. By bottling the mixture as above, no mistake need be made in using it of proper strength."

Whale-oil soap.—A preparation made of fish oil with lye. Effectual against scale insects and plant lice, and when mixed with carbolic acid makes an excellent deterrent for borers. When used as a spray for plant lice, the proportions should be:

Whale-oil soap	grams..	450
Water	liters..	45 to 90

This should be thoroughly dissolved before using, and the weaker solution is advised for trees when in young leaf. Even 450 grams to 125 liters of water is not too weak. If ordinary soft soap or turpentine soap be used the following are the proportions:

Common soap	grams..	450
Water	liters..	18 to 36

Another excellent preventive which has been used most successfully against the peach borer in the United States, and which would probably prove of equal value to that of the carbolic wash, is what is known as the lime, coal-tar and whale-oil soap wash. It is prepared according to the following formula:

Unslacked lime	kilos..	25
Coal tar	liters..	6
Whale-oil soap	kilos..	6

The lime and tar should be slacked together with water sufficient to make the whole of the consistency of white paint. The whale-oil soap is dissolved in hot water and added to the lime and tar solution. When water is added sufficient to make the whole mass as thick as ordinary thick paint, it may be applied to the tree.

Tobacco wash.—This very effectual remedy against plant lice has certainly the advantage of cheapness in a country where tobacco is abundant. It is applied as a spray after being prepared as follows:

Dry stems or tobacco leaf	grams..	225
Water	liters..	4.5

Steep over a slow fire for some hours, then, when ready to use it, dilute the quantity with 25 to 50 gallons of water.

Carbon bisulphide.—This is a colorless liquid, resembling refined kerosene in appearance. It is of a very disagreeable odor and extremely volatile. It can not be handled around fires, and even smoking while using it is dangerous. It is explosive and also takes fire very readily. Its vapor is heavier than the air; hence it should be placed above whatever it is desired to fumigate. In closed bins or in rooms the proportions to be used are 450 grams for every 27 cubic meters, or 17 grams for every cubic meter. Whatever it is placed into should be perfectly tight in order that the fumes may not escape.

Bordeaux mixture.—This valuable fungicide has as its essential ingredient the sulphate of copper, commonly called blue vitriol or bluestone. It is prepared as follows:

Copper sulphate or blue vitriol	kilos..	1.80
Quick lime (unslacked)	do....	2.25
Water	liters..	225

The copper sulphate should be dissolved in half of the amount of water, or 100 liters, in a wooden vessel, such as a half barrel. The lime should be slacked in the remainder of the water, and when ready for use the two solutions should be poured together into the spray-pump barrel or tank. In order to save time a stock solution of each substance should be made and kept on hand.

First slack in a wooden vessel 22.7 kilos of lime. This should be immediately strained into a barrel holding 225 liters and the barrel filled with water. Cover the barrel to prevent foreign matter from getting into it.

The copper sulphate stock solution should be prepared by dissolving 18.1 kilos of the crystal in 225 liters of water and putting it into a barrel, covering the same.

When it is desired to use Bordeaux, take 22.5 liters of each solution and add enough water to make 225 liters of the Bordeaux mixture.

At the present time the question of spraying in the Philippines is a very serious one, owing to the fact that none of the goods of large and reliable firms of spray-pump manufacturers are represented in the Philippine market. For several years past the United States Government has carried on experiments for ascertaining the best apparatus for combating insects on a large scale, and, as a result of its work and the experimentation of individuals, there are now upon the American market several very excellent spray pumps which, considering the ease of manipulation and the fact that they will last for several years if given proper care, are very reasonable in price.

The principal essentials of a good spraying apparatus are that it deliver a fine spray, that it keep the mixture to be sprayed in constant agitation in order that the ingredients may be kept in uniform suspension, and that it have sufficient capacity so that a reasonable amount of the insecticide may be made and used at one time.

The two types of spraying apparatus which would give the best results in cacao plantations are the barrel pump and small power spray pump. The former would be useful in small plantations of not more than two or three hectares and the latter for large ones. With a barrel pump and two nozzles and three men to operate it in the orchard, from 50 to 75 cacao trees could be sprayed in a day. With the power spray pump a proportionately larger number of trees can be treated. The best nozzle is one which will break the liquid up into the finest particles possible and at the same time is not liable to clog, or, if clogged, may be easily cleaned.

Partial Report of the Work of Mr. J. J. Eaton, Preparer of Wood Sections in the Bureau of Government Laboratories for use of the Bureau of Forestry.

This report simply gives an outline of the methods employed and the class of microphotographs produced. The complete work will be published by the Bureau of Forestry.

Forty-eight samples of different kinds of woods taken from trees in the Philippine Islands were received, and sections of them cut. All of the commercial groups of wood were represented, there being 8 of the superior groups, 3 of the first, 13 of the second, 7 of the third, 4 of the fourth, 1 of the fifth, and 12 not in the classified list.

Almost all of the samples received were 2 cm. square and 4 cm. long. From these small pieces were cut in such a manner that surfaces parallel to the annular rings, parallel to the medullary rings, and cross sections were obtained. These surfaces were about 12 mm. square and not over 3 mm. in thickness. It is recommended that hereafter the samples submitted be at least 10 cm. square and 5 cm. thick, in order that the tissues may be properly selected.

The first step consisted in finding some method of softening the wood tissues and of removing all salts and other substances that might interfere with the sectioning, and yet not destroy or rupture the cells of the material.

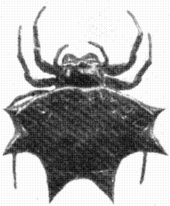
Various suggestions were obtained from the work The Microscope and its Revelations, by W. B. Carpenter, but they were not applicable to most of the hard-wood specimens received. Some of the methods suggested were tried as follows:

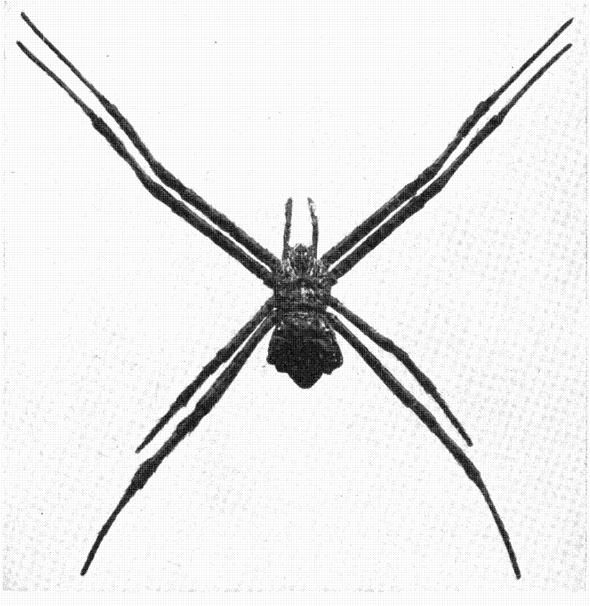
Several small pieces of the wood "tua" were boiled in a 10 per cent solution of nitric acid for ten minutes, then placed in hot alcohol, not boiling, for thirty minutes, and afterwards boiled in water for fifteen minutes. These pieces were not softened to such a degree as were others by a different method, while the surfaces appeared to have been attacked by the nitric acid. They were consequently discarded, together with the method.

Samples of the wood "balete" were boiled for ten minutes in a 2 per cent solution of acetic and chromic acid, but were not softened. New pieces of the same wood, boiled fifteen minutes in a 10 per cent solution of the same acids, were not softened. As very little coloring matter was removed by this method, it was discarded.

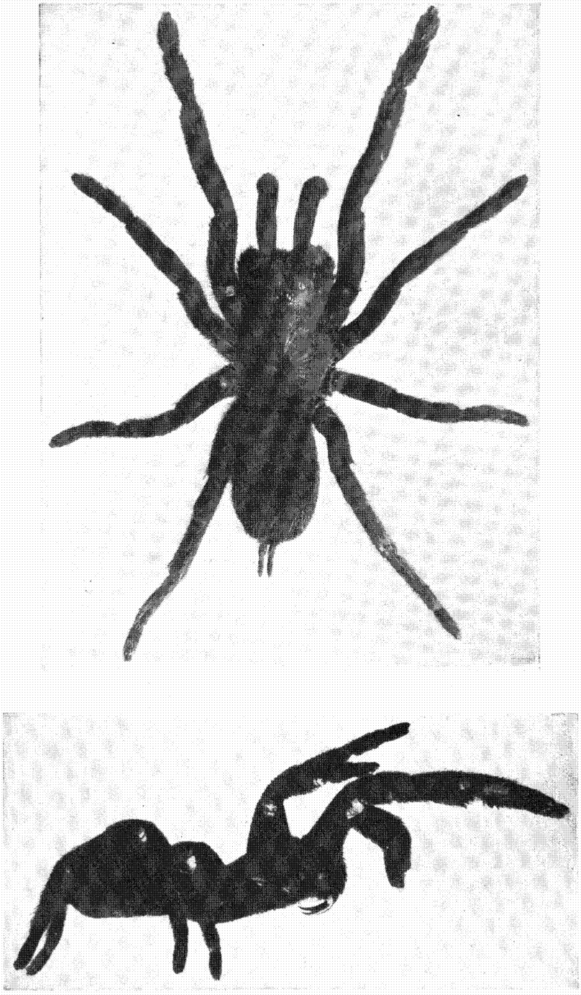
Boiling "acle" in a 10 per cent solution of nitric acid and chlorate of potassium for fifteen minutes failed to produce the required degree of softness. This method might have produced the desired results, but the extreme care necessary in order to avoid an explosion made it undesirable, especially as another method gave satisfactory results.

At the time these experiments were being made, samples of "tindalo" and "narra"

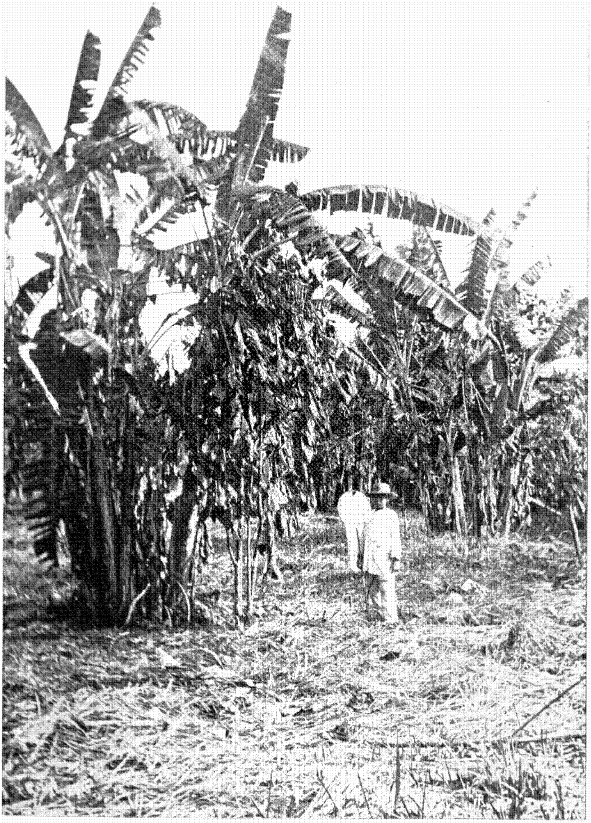




SPIDERS FROM CACAO TREE.



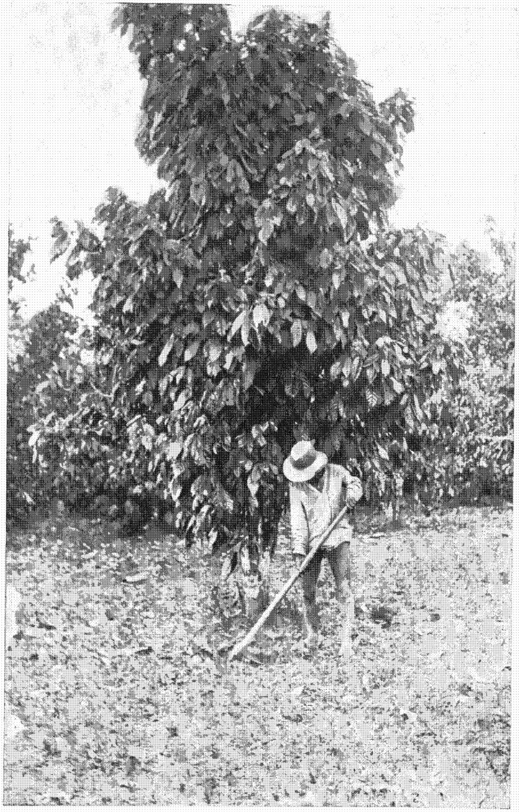
TARANTULA FROM BASE OF CACAO TREE, SHOWING FANGS IN LOWER FIGURE.



CACAO OVERSHADOWED BY BANANAS—GROWTH STUNTED.

TEMPORARY FIELD LABORATORY OF ENTOMOLOGIST NAKALANY MAAO, OCCIDENTAL NEGROS.

GENERAL VIEW OF CACAO ORCHARD.



WORKING CACAO ORCHARD, PRIMITIVE METHOD.

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were placed in 10, 20, 30, 40, and 50 per cent solutions of hydrate of potassium, corked, and allowed to remain for twenty-four hours. No appreciable softening was noticed, but a great deal of coloring matter had been extracted. The second day showed a slight softening, and this was increased from day to day, the "tindalo" always being softer than the "narra" in corresponding solutions. The degree of softness varied in direct proportion to the strength of the solution, which was from 10 to 50 per cent. In two days the pieces in the 50 per cent solution showed an apparent deterioration of the surfaces. Those in the 10 per cent solution showed but a slight degree of softness. There was but little difference in the other three solutions. In nine days it was almost impossible to detect a difference in the colors of the solutions containing the same kind of wood. The "tindalo" was quite soft in all the solutions excepting the 10 per cent, which was therefore discarded. The 50 per cent solution was likewise dropped on account of the deterioration of the wood, and also of the glass containing the solution.

There being very little difference in the softness of the three remaining specimens, verified by an examination of the "narra," the 20 per cent solution of KOH was adopted as the preferable method for softening wood tissues.

Previously, solutions of 1, 2, and 3 per cent of caustic potash were tried with unsatisfactory results. Possibly a solution somewhere between 10 and 20 per cent would give the best results. At any rate the 20 per cent solution proved satisfactory.

After adopting this method of softening the wood tissues, various samples were placed in test tubes containing a 20 per cent solution of caustic potash, and tightly corked. The latter precaution was taken in order to prevent absorption of moisture from the atmosphere. Only one kind of wood was placed in each receptacle in order to avoid confusion and a possible change in color, but the three different sections of the same piece of wood were placed in the same receptacle. It was thought advisable to treat three samples of each section in order to provide for any accident or emergency that might arise in subsequent operations.

Although the microscope reveals the character of the section, whether cross, parallel to the annular rings, or parallel to the medullary rings, it is much more satisfactory to indicate the difference in the mounted tissues. Each of the three kinds of sections should, therefore, be cut in some distinguishable shape or size before being placed in the softening solution. Two or three millimeters is ample for the thickness of a piece, and the other dimensions need not exceed 1 cm., except for special work.

Some woods were apparently softened in from four to seven days, but later were discarded for others that had been in the softening solution for a longer time. The latter gave much better sections.

The woods requiring from seven to ten days for softening are tindalo, narra (two varieties), supa, ipil, tua, bitanhol, calingag, bolobo, balete, calumpit, sibucao, parua, alintatao, betis, dugonlate, lauan, malibago, apitong, pansainguin, piripilim, bangat, santol, and pamiasin, which constitute half of the samples treated.

Those requiring from fifteen to eighteen days are panao, guijo, palo maria, agoho, lisong insoc, mambog, camagon, anonag, and anilao.

From eighteen to twenty-four days are required for acle, batino, magalat, yacal, and balaybayan.

Those which were not softened after the last-named period had elapsed were placed in a new solution of caustic potash and boiled under a pressure of 1 atmosphere for three-fourths of an hour with the results that two of the specimens became quite soft, namely, malamhat and molave.

Uayan, alupag amio, tarrieta, aranga, and bolongeta were again placed in the autoclave and boiled under the same pressure for three-fourths of an hour longer, making one and one-half hours in all. At the end of this time they were quite soft.

In two hours ebano was sufficiently softened, when treated in the same way. Macapali and payina are still under treatment, having recently been received.

After the specimens had been softened the caustic potash in the tissues was removed by boiling them in water. From one to two hours was sufficient to accomplish this. Those having a large amount of coloring matter are tindalo, both narra samples, supa, ipil, bitanhol, camagon, calumpit, yacal, sibucao, balaybayan, ebano, tarrieta, aranga, bolongeta, apitong, santol, and pamiasin.

After each specimen had been freed from the KOH, it was dehydrated by passing it through successive baths of alcohol of increasing strength. First 80 per cent alcohol was used for twenty-four hours, then 95 per cent, and finally absolute for the same length of time.

After removing the water, the cells were filled with a supporting material (celloidin) by placing the specimens in alcohol and ether for twenty-four hours, thin celloidin for forty-eight hours, and thick celloidin for the same period.

These tissues were mounted in thick celloidin on wooden blocks and preserved in 80 per cent alcohol. As the tissues cut best when the microtome knife moves in the direction of the grain of the wood, they were mounted accordingly. A slight distortion in some of the more delicate cells seemed to indicate that a longer time—five to seven days in thin celloidin—would have been preferable to two days. The blocks for mounting were selected from a wood that gave no color to the alcohol.

After a few hours had elapsed the tissues were ready to be sectioned in the microtome. Both the knife and the wood were wetted with 80 per cent alcohol during this operation. The sections varied in thickness from 15 to 30 microns according to the kind of wood, and in all cases were the thinnest obtainable without rupturing the cells. Naturally soft woods gave thinner sections than hard woods, and cross sections were the thickest and most difficult to cut. These were usually about 5 microns thicker than the other sections of the same wood. Until mounted on slides these sections were preserved in 80 per cent alcohol.

Four sets of each kind of section were mounted on slides, two stained and two unstained. The stained sections were prepared by placing them first in water for a few minutes to remove the alcohol, from water to hæmatoxylin stain for five to ten minutes until fully stained, to water again for a few minutes to wash, to acid alcohol for a very short time to remove excess stain, and to water again with a few drops of ammonia until blue color was restored, after which they were dehydrated with 80 per cent, 95 per cent, and absolute alcohol. They were then placed in creosote until clear, removed to slides, blotted, and after an application of balsam, cover glasses put on.

When the sections were not stained the first part of the process was omitted. Beginning with 95 per cent alcohol they were then treated in the same way as the stained sections.

The total number of slides prepared is 170.

Receipts.

[NOTE.—Private work charged for beginning February, 1903; public work from March, 1903, except vaccine, which was charged for from February 4, 1903. Charges for work for insular bureaus ceased July 1, 1903.]

[Mexican currency.]

	February.	March.	April.	May.	June.	July.	August.	Grand total.
Private work	$58.00	$99.00	$136.45	$323.50	$207.20	$178.30	$21.00	
Board of health		2,487.00	2,580.00	1,566.00	2,876.00			
Civil hospital		664.50	694.00	468.00	656.00			
Bilibid prison		141.00	54.00	90.00	176.00			
Prosecuting attorney			150.00		15.00			
Exposition board			263.00	7.00	126.00			
Bureau engineering			84.00					
I. C. S. and I. P			8.00					
Constabulary			35.00					
Philippine Commission				21.00				
Quarantine service				12.00				
Bureau public works					75.00			
Attorney-general		10.00						
Headquarters Division of Philippines				43.00				
Benguet Sanitarium				6.00				
Police department, Manila						15.00	9.00	
Provisional board of health, Occidental Negros							1.00	
Total	58.00	3,401.50	4,004.45	2,536.50	4,131.20	193.30	31.00	
Sale of calves (U. S. currency)						330.00		
	58.00	3,401.50	4,004.45	2,536.50	4,131.20	523.30	31.00	$14,685.95
Private work (U. S. currency)			11.00	12.00	26.45	2.60	9.80	
Board of health (vaccine) (U.S. currency)	2,379.53	1,839.68	3,459.00	1,500.00	738.00			
Serum of private parties (U. S. currency)							375.00	
Total	2,379.53	1,839.68	3,470.00	1,512.00	764.45	2.60	384.80	10,353.06

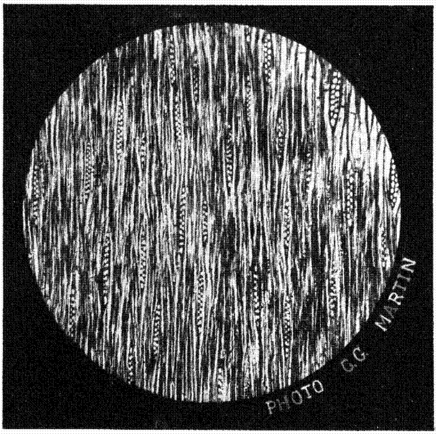

FIG. 204.—TANGENTIAL SECTION OF TINDALO.

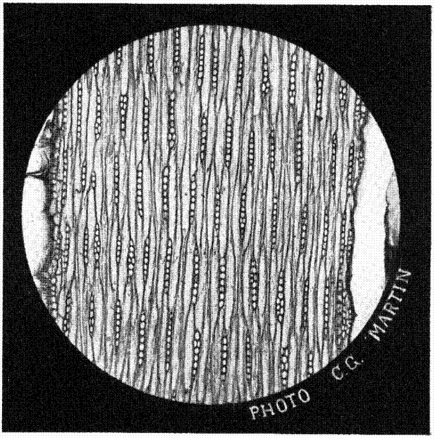

FIG. 205.—TANGENTIAL SECTION OF NARRA.

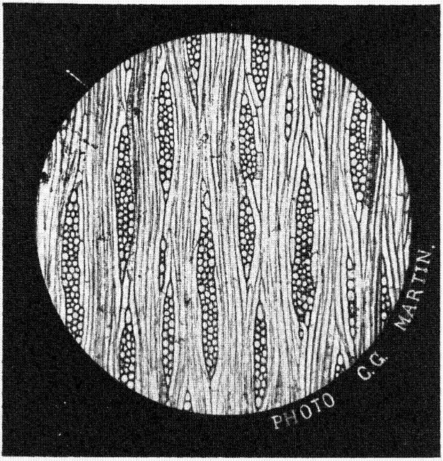

FIG. 206.—TANGENTIAL SECTION OF SUPRA.

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